DOCUMENT RESUME

ED 059 605 88 EM 009 601

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TITLE Variable Modular Scheduling Via Computer Developed by Stanford University and Educational Coordinates, Inc.
INSTITUTION American Institutes for Research in the Behavioral Sciences, Palo Alto, Calif.
SPONS AGENCY Office of Program Planning and Evaluation (DHEW/OE), Washington, D.C.
REPORT NO AIR-21900-12-71-TR-9
PUB DATE Dec 71
CONTRACT OEC-0-70-4892
NOTE 97p.

EDRS PRICE MF-$0.65 HC-$3.29
DESCRIPTORS *Computer Programs; *Educational Objectives; Flexible Schedules; *Flexible Scheduling; *Schedule Modules; Scheduling; School Schedules
IDENTIFIERS *Variable Modular Scheduling Via Computer

ABSTRACT

Variable Modular Scheduling Via Computer, a scheduling program which focuses on allocating a school's resources according to the school's overall purposes, is designed to allow schools to adapt organizational patterns to whatever teaching and learning patterns they define as necessary in meeting their educational goals. The system's rationale, materials, and procedures for use are described in the first section of this report. The origins of the project are considered and information is provided about key personnel, sources of ideas for the product, evolution of ideas for the product, and funding for product development. A section on product development details the history of the management and organization of the project, the original development plan, actual procedures for development, and a formative evaluation. Diffusion strategies and efforts are discussed, and product characteristics affecting diffusion are described. Information about the extent of product use, installation procedures, and successful implementations is included. Speculations about the future of the product and a list of crucial decisions made in the 11-year history of its development conclude the report. Appended are descriptions of some successful implementations of the product. (SH)

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PRODUCT DEVELOPMENT REPORT NO. 9

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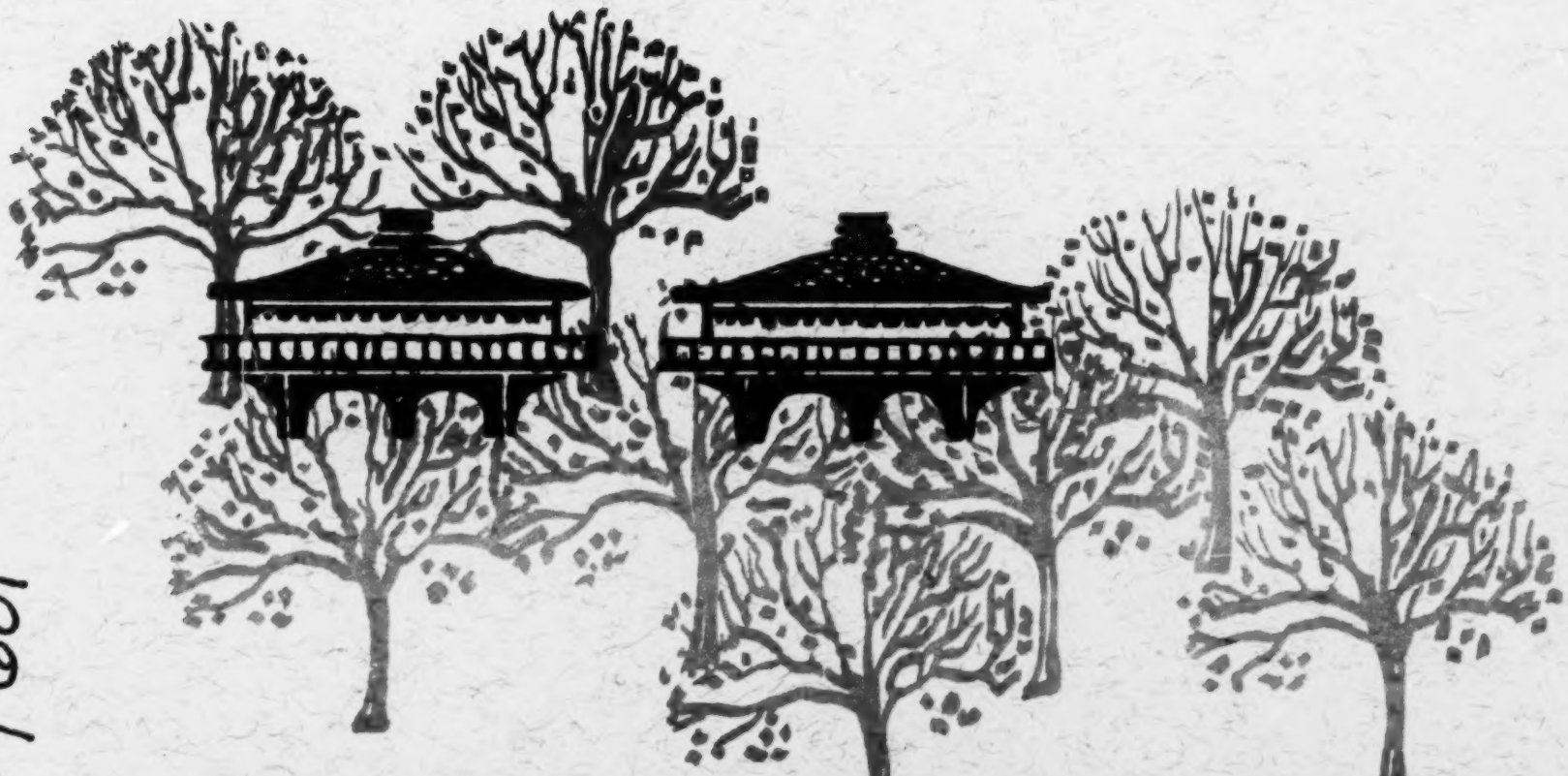
VARIABLE MODULAR SCHEDULING VIA COMPUTER

DEVELOPED BY

STANFORD UNIVERSITY AND EDUCATIONAL COORDINATES, INC.

December, 1971

Contract No. OEC-0-70-4892



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The research reported herein was performed pursuant to a contract with the Office of Education, U.S. Department of Health, Education, and Welfare. Contractors undertaking such projects under Government sponsorship are encouraged to express freely their professional judgment in the conduct of the project. Points of view or opinions stated do not, therefore, necessarily represent official Office of Education position or policy.

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PREFACE

This product development report is one of 21 such reports, each dealing with the developmental history of a recent educational product. A list of the 21 products, and the agencies responsible for their development, is contained in Appendix B to this report. The study, of which this report is a component, was supported by U.S. Office of Education Contract No. OEC-0-70-4892, entitled "The Evaluation of the Impact of Educational Research and Development Products." The overall project was designed to examine the process of development of "successful educational products."

This report represents a relatively unique attempt to document what occurred in the development of a recent educational product that appears to have potential impact. The report is based upon published materials, documents in the files of the developing agency, and interviews with staff who were involved in the development of the product. A draft of each study was reviewed by the developer's staff. Generally, their suggestions for revisions were incorporated into the text; however, complete responsibility for interpretations concerning any facet of development, evaluation, and diffusion rests with the authors of this report.

Although awareness of the full impact of the study requires reading both the individual product development reports and the separate final report, each study may be read individually. For a quick overview of essential events in the product history, the reader is referred to those sections of the report containing the flow chart and the critical decision record.

The final report contains: a complete discussion of the procedures and the selection criteria used to identify exemplary educational products; generalizations drawn from the 21 product development case studies; a comparison of these generalizations with hypotheses currently existing in the literature regarding the processes of innovation and change; and the identification of some proposed data sources through which the U.S. Office of Education could monitor the impact of developing products. The final report also includes a detailed outline of the search procedures and the information sought for each case report.

Permanent project staff consisted of Calvin E. Wright, Principal Investigator; Jack J. Crawford, Project Director; Daniel W. Kratochvil, Research Scientist; and Carolyn A. Morrow, Administrative Assistant. In addition, other staff who assisted in the preparation of individual product reports are identified on the appropriate title pages. The Project Monitor was Dr. Alice Y. Scates of the USOE Office of Program Planning and Evaluation.

Sincere gratitude is extended to those overburdened staff members of the 21 product development studies who courteously and freely gave their time so that we might present a detailed and relatively accurate picture of the events in the development of some exemplary educational research and development products. If we have chronicled a just and moderately complete account of the birth of these products and the hard work that spawned them, credit lies with those staff members of each product development team who ransacked memory and files to recreate history.

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PRODUCT DESCRIPTION

Product Characteristics

Name

Variable Modular Scheduling Via Computer (referred to in the text simply as Variable Modular Scheduling).

Developer

Stanford University and Educational Coordinates, Inc.; the latter is based in Sunnyvale, California. In the mid-1960's Stanford University developed computer techniques and educational rationale which resulted in the Stanford School Scheduling System. This system is a set of computer programs that were released to the public domain in 1968. Educational Coordinates picked up the system for a nominal fee, extensively modified it, and is now disseminating it under the name of Variable Modular Scheduling Via Computer.

Distributor

Educational Coordinates, Inc.

Focus

Variable Modular Scheduling Via Computer focuses on allocating a school's resources (e.g., time, personnel, and facilities) according to the school's overall purposes. The product is designed to allow schools to adapt organizational patterns to whatever teaching-learning patterns they define as necessary in meeting their educational goals.

Grade Level

Kindergarten through grade 12.

Target Population

The target population consists of all students, kindergarten through grade 12. Variable Modular Scheduling invariably results in unscheduled or "free" time for students, and there has been criticism suggesting that some students (e.g., those who do not use free time effectively) do not benefit from such scheduling. The developers point out, however, that if the product (i.e., the schedule that is produced) is used effectively, all students will benefit, as more consideration will be given to individual differences.

Rationale for Product

Long Range Goals of Product

A long range goal for Variable Modular Scheduling is to enable experimentation with and implementation of innovative educational practices. Educational Coordinates foresees a modest growth of use of the product, as has been the case up to now. A possible extension of Variable Modular Scheduling might be what is called "interactive scheduling" which would allow on-line interaction. It would be possible to anticipate major problems and make corrections before being locked into a computer-fixed schedule. Since trends in education, e.g., individualized instruction, tend to make scheduling even more complex, computer assistance is expected to continue to be necessary.

Objectives of Product

Constructing a school schedule of whatever kind is a question of how best to allocate finite resources of time, personnel, and facilities according to some definition of organizational purposes. The year's "master schedule," a perennial headache to school administrators, simply tells what courses are offered, when and where their classes will meet, and who will be there (teachers, students). Variable Modular Scheduling is a computerized method of constructing a school's master schedule. It differs from some other kinds of computer scheduling in that it actually constructs the entire master schedule, rather than merely "loading" students into an already existing schedule of classes manually prepared by the school. Its method of doing this gives first priority to fulfilling student course requests with a minimum of conflicts. By encouraging variable course structures, teachers are allowed to design their courses around what they consider to be the unique educational requirements of their subject matter in contrast to fixed time periods or standard-sized student groupings. For example, the science teacher can plan a long laboratory session meeting only once or twice a week, a typing teacher can devise shorter but more frequent practice sessions, a social studies teacher can plan one large lecture meeting plus several smaller group seminars, and so on.

The objectives of flexible scheduling can be summarized in one word: "enabling":

1. Enabling the effective implementation of some widely accepted current educational theories and practices.

2. Enabling a process of evolving experimentation.

The second process-oriented objective is based on the limitations of the first. That is, since no one has the real answers to what the best teaching-learning strategies are, a good place to start is in making experimentation easier. Let both teachers and students ask such questions as, "how should this subject best be taught?" Then try various alternatives and revise on the basis of experience--throw out what doesn't work, build on what proves effective, and gradually evolve the patterns that get the best results. It does indeed enable experimentation--hence the public reaction in some quarters that "they're making guinea pigs out of our kids." However, it does as readily provide for discard of what does not work. The theory is that the opportunity to evaluate feedback and redesign course structures each year will result in professional growth of teachers and improved programs for students.

The following are some of the current educational theories and practices which the developers state are encouraged by Variable Modular Scheduling:

- Student responsibility for learning--self-direction, decision making, and choice.
- Instructional objectives and learning based on performance criteria instead of "time spent."
- Multi-media instruction and resource centers.
- Process- and concept-centered curriculum.
- Non-gradedness, individualization.
- Professional teacher development, team teaching, and use of paraprofessionals
- More intimate and meaningful individual teacher-student relationships.
- Student-to-student tutoring.

The developers pointed out that Variable Modular Scheduling is only as good as the use that is made of it. To introduce complex patterns of variability only to continue teaching in the same old way is merely to complicate

the schedule and create more problems than gains. It is only justified by improved curriculum design and better teaching and learning.

Philosophy and Theories Supporting Product

Even with a relatively simple, conventional arrangement of the school day, a conscientious high school administrator has to allocate thousands of man-hours to construct class meeting patterns that will minimize student course conflicts within all the restrictions of time, teacher assignments, and available rooms. A mountain of paperwork accompanies this, such as course lists, student course assignments, the schedule of class meetings, the lists of students assigned to each class, teacher assignment lists, room allocation records, and so on.

That this school scheduling problem is a very real one is further evidenced by the fact that one of the first areas in which computer data processing was applied in education (after payrolls, attendance, test scores, and other such clerical record-keeping) was that of assigning students to class sections within a previously hand-developed master school schedule.

The developers of Variable Modular Scheduling compare their approach to what they call the traditional high school "eggcrate schedule" to dramatize its uniformity. The "eggcrate" is a long hallway with rooms on each side, occupied by a teacher and a uniform number of students (30) for a uniform period of time (55 minutes) until the bell rings; whereupon, after some reshuffling the eggcrate "slots" are filled again. Such a schedule, they say, subordinates educational concerns to administrative convenience. Not only are all students expected to master course content in the same way at the same rate, but also the different capabilities of different teachers are not efficiently used, and curriculum innovation is restricted.

In contrast to the eggcrate analogy, Variable Modular Scheduling may be compared to a jigsaw puzzle in which varying configurations of time, class size, teacher assignments, room arrangements, and course offerings are fitted together. The theory is that this will be done according to optimum instructional patterns for both subject areas and student needs. This jigsaw puzzle is always missing some pieces, which add up to "unscheduled time." In itself this has an educational rationale in non-structured learning (e.g., independent study). Instead of being confined to a study hall in one or two non-class periods, the student typically has 35-45 percent of

his time free as an individual resource to be allocated--to independent study, to remedial work where he is weak, to special projects according to his individual interests, to conferences with instructors--theoretically, to whatever will contribute most to his own educational needs and goals. It also makes possible experimental curriculum expansion in the form of "mini-courses," wherein a group of students with a common special interest (say oceanography) may be able to meet with a teacher whose own unscheduled time fits theirs.

A primary characteristic of Variable Modular Scheduling, discussed more fully below, is variable course structuring. Another characteristic is the use of smaller and, therefore, more time units (often 20 minutes), called modules, than in a traditional schedule. A module is simply a building block of time specified as the minimum instructional time period of the school day. When this kind of variability--in course structures, class size, and many possible combinations of time periods--is introduced into a school schedule, its complexity increases enormously. Another effect of variability is an increase in the number of courses that can be offered, resulting in a greater variety of student course requests. The "jigsaw puzzle" is a three-dimensional one, and the scheduling problem of assigning students, teachers, and rooms is analogous to filling a cubical box with wood blocks of varying shapes and sizes (triangles, rectangles, spheres, pyramids). If the wood blocks totaled the same cubic volume as the box, they would still not fill it uniformly. The pieces would not be compatible with each other, and even in a larger box there would be empty spaces. The empty spaces add up to "unscheduled time" for both teachers and students. In building a variable modular schedule, the degree of incompatibility is measured in terms of "variability" and "scheduling density."

Scheduling density is the ratio of time in class to the total time available. In a traditional schedule where the blocks of wood are uniform cubes, there are no spaces when the box is filled and the scheduling density is 100 percent. A student is scheduled for every minute of the school day. But in a variable schedule, both teachers and students have scheduling densities that range from 50 percent to 75 percent, leaving 25 to 50 percent of their time "unscheduled." When variability goes up, density goes down. That is, a scnool that places a premium on high density (having the student scheduled for most of the total time) will not be able to offer as much in

its course structures (e.g., time, group size, etc). A school wanting very complex kinds of course structuring will inevitably come out with a considerable amount of unscheduled time because of the incompatibility of the parts.

The basic function of varying time and class size is to make possible innovative course designs and instructional alternatives. A course is a body of subject content (e.g., English Composition, Biology, Introductory Algebra, etc.); a course structure is the way teacher, students, and facilities are organized to accomplish the instructional objectives defined for the course. The variability comes in manipulating time per meeting, meetings per week, group size, and teacher assignments to allow a course to be structured according to differential instructional modes. In Variable Modular Scheduling terminology the different elements of a course structure are called "phases." A phase is defined by size of group, length and frequency of meetings, and instructional mode. A traditional high school course is usually a single-phase course, meaning it has a uniform structure: 30 students and one instructor meet five days a week for a 55-minute period each day. Variably structured, a course becomes multiphased. The simplest variation from this could give a two-phase course where, for example, two American History sections (60 students) meet together on Monday for a 55-minute lecture and meet separately in the above pattern the rest of the week. More complex multiphased structures can best be discussed in terms of the main instructional phases identified in variable course structuring.

Structuring a course in different phases is done by asking some variant of the following questions:

1. What can students learn best from explanation by others?

2. What can be learned best through personal or group interaction?

3. What can students learn by themselves, with the teacher considered as one resource among others?

The developers have identified the following four major phases:

1. A <u>presentation</u> phase, implying large-group, one-directional instruction (e.g., lecture, film presentation, guest speakers).

2. A <u>discussion</u> or <u>problem-solving</u> phase, typically meaning sectioning the course enrollment for small-group meetings. This implies student-to-student and student-to-teacher interaction (role-playing, discussion, drill and practice, etc.).

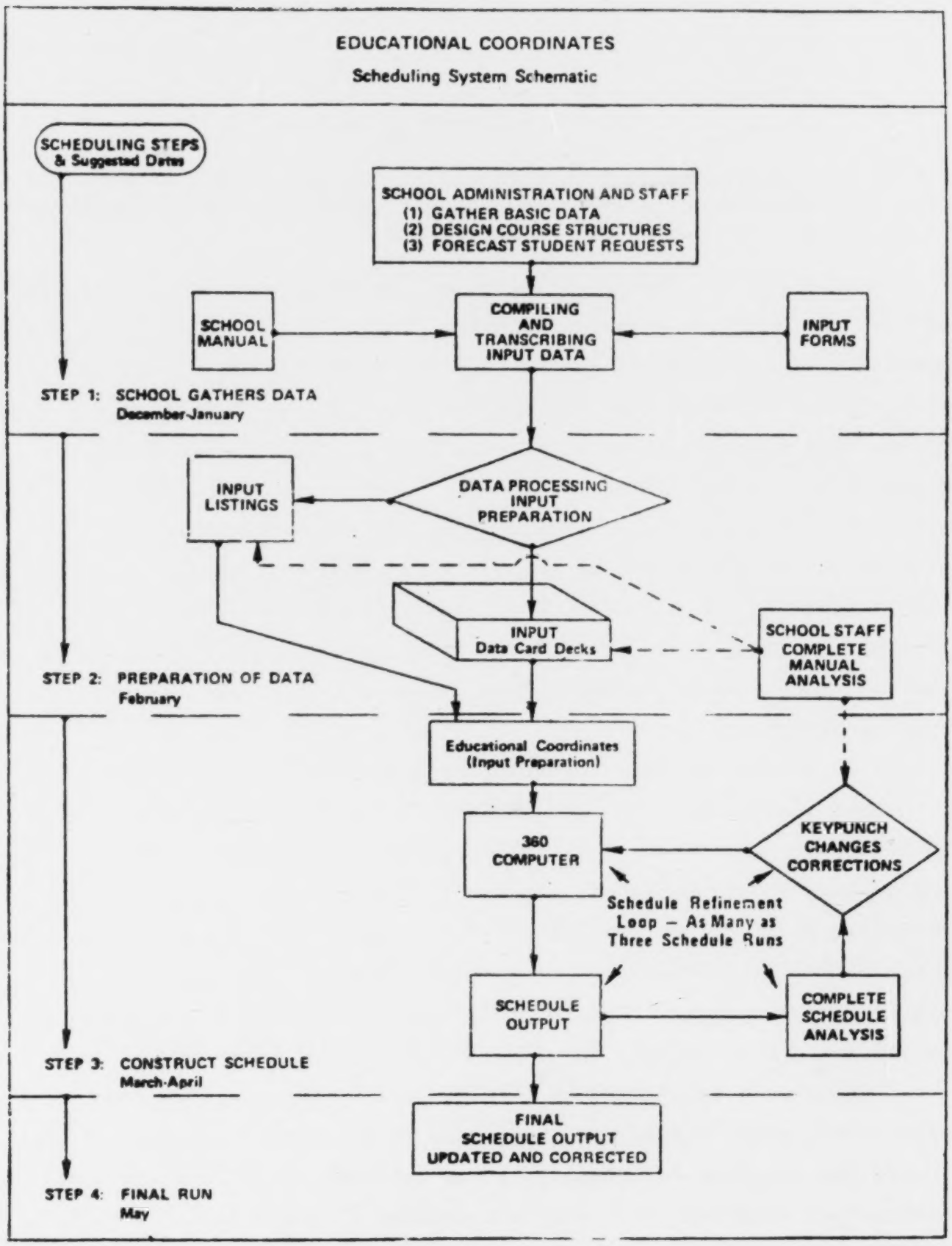
3. A laboratory phase, typically requiring special facilities and thus limiting the number of students who can participate at any one time. As used in Variable Modular Scheduling, any subject in which students do experiments, practice, use audiovisual equipment, and so on, is utilizing the laboratory mode (e.g., foreign language laboratories, art, music, or reading resource centers, home economics, science). It usually means teacher supervision, but need not.

4. A nonstructured (not formally scheduled) phase, wherein the student is expected to use a portion of his unscheduled time for independent study in the course.

One of the results of multiphasing can be greater staff differentiation without increasing the overall teacher/pupil ratio. Team teaching, tutorial sessions, and small-group instruction can be facilitated. Regular interdisciplinary meetings can be arranged by scheduling a phase of two courses at the same time (e.g., science and social studies classes might meet together to explore ecological issues). Or, various combinations can be structured within the same course by dividing it into sub-courses. American history can be subdivided by subject into economics, social/cultural history, immigration and urbanization, etc.; students can meet for a common core of instruction in one phase, then meet in the sub-courses with teachers with special competencies in those areas. Subdivision by ability groupings is another approach.

All these scheduling alternatives also have implications for the use of school facilities. The use of time as a resource like any other and the variable structuring of courses forces some examination of the way facilities and equipment are allocated. Resource centers containing a wide variety of materials in a certain subject are desirable so that students may pursue activities in them during their unscheduled time. Many schools add an audio-visual center. Another result of unscheduled time is a tremendous increase in library use throughout the day. Another development has been the "open lab," where such facilities as science laboratories, typing rooms, industrial arts areas, music rooms, etc., are open at all times to students, whether for completing required assignments or for optional use during unscheduled time. With proper planning, this approach enables a single facility to be used by different kinds of students or courses at the same time. Students need not be treated identically in identical blocks of time. On the same level, some

Figure 1. Steps in Building a Master Schedule



(Educational Coordinates Flexible Scheduling School Manual, 1969, p. 00.15)

may progress faster than others, and advanced students may spend less required time than beginning students.

Description of Materials

Organization, Format and Content of Materials

The product that the schools buy is a printed schedule that allocates the school's resources of time, personnel and facilities according to the school's overall organizational purposes. Figure 1, taken from the Educational Coordinates School Manual (1970), shows the major steps and dates in the building of such a master schedule.

The school sets the timeline; often the school starts its input around December or January in order to get by June or earlier a final schedule ready for the start of school in September.

In building a variable schedule, this much time is often required for the preparation of the input data by the schools, analysis by the scheduling consultants of the school's use of the many special features, data processing and cleanup for input to the computer, and analysis by both school and scheduling consultant of the first prediction model of the schedule and the up to two additional schedule runs. The proper specification of features such as periods per meeting, section size maximums, and interphase dependencies, take the most school and consultant time. Besides initial data processing, all changes between computer runs require extra processing to update the data.

The actual computer time it takes to build the master schedule is minimal. Stanford University once generated seven different master schedules for a school within one week's time. Also, an uncomplicated traditional schedule can conceivably be done from initial input to final form within one to two weeks, because the data is simple and little analysis is necessary.

Step 1 (see Figure 1) is almost entirely the school's responsibility. Educational Coordinates gives schools a kind of "watch for" memorandum with suggestions for questions to be considered by a school staff first moving to a variable modular schedule. The Educational Coordinates School Manual gives very detailed step-by-step technical instructions for compiling and transcribing input data on forms given to the school. The school decides

on curriculum offerings, course patterns, what facilities are to be used, which teachers will teach what, and which students will be allowed to take what courses.

Step 2, the preparation of the input data cards, can be done either by the school or by Educational Coordinates, depending on whether the school elects to do its own keypunching or contracts for keypunching services from organizations other than Educational Coordinates. In any case, the input data are keypunched from the forms submitted and computer-audited for logical errors (e.g., a student request for a nonexistent course).

Educational Coordinates will make suggestions during Steps 1 and 2, based on experience, to help schools with input preparation. For example, they will suggest that a school assign student numbers alphabetically within grades to facilitate finding students when corrections are necessary and to make the final printout come out alphabetically by grade level. Or, they may suggest that a school will find it helpful to design its form for student course requests to include course name as well as number--this cuts down the number of careless errors by students and makes it much easier to find and correct errors that do occur.

Step 3, the actual construction of the schedule, is where Educational Coordinates' major production activities fall. These include the analysis by the scheduling consultant, especially after the first run, and then the back and forth consultation with the school to try to resolve barriers to a successful schedule. This is done between each successive schedule generated until a satisfactory schedule is reached. An example of a predictive report to a school on scheduling difficulties might go something like this (very condensed version):

> . . . Your teacher and student densities are too high for the complexity of the schedule, giving a potential for far too many conflicts. Your schedule complexity is related to a high percentage of single-phase courses along with a high percentage of multi-phased courses requiring interphase dependencies; and a large number of courses meeting 5 to 6 times a week, as well as too many course phases meeting for long period lengths. . . .

There would then follow suggestions from the scheduler and re-analysis of requirements by the school until some compromise was reached. A school need not follow the suggestions nor make the compromises, and if the resulting final schedule is as unsuccessful as predicted, the school has to live

with it. Thus, in Step 3, various refinements can be made, such as better balancing of specific class sections, changing selected teacher or room assignments, assigning late registrants, and changes in student course requests.

Up to three master schedule constructions are allowed by contract with the schools. In each construction, the computer builds the master schedule from data supplied by the school in terms of three main dimensions: time periods, course structures and class sections, and resource assignment (students, teachers, rooms).

In Step 4, the final master schedule is printed in school language in the form of multiple copies of class lists, student and teacher schedules, and room schedules. Once the final master schedule is built, and when school starts, it becomes the school's responsibility to effect any necessary changes manually. Figure 2 shows an example of a student's schedule developed by Variable Modular Scheduling.

Cost of Materials to User

The basic contract price to a school is computed on the basis of a flat rate plus a per student charge. The former goes up according to school size and the latter goes down, reflecting the heavy weight of start-up costs for the scheduling firm. The flat rate ranges from approximately $1,200 for small schools up to about $4,500 for large schools. Per student charges range from around $2 for a large school to around $5 for a small school. Very small schools may be charged only the flat rate. Discount arrangements can be made for scheduling several schools in the same school district, and adjustments may sometimes be made in terms of the nature and extent of the variability involved. (The above gives only a general picture, because obviously each contract is negotiated individually and many factors enter into it.)

The basic contract provides the school with up to three master schedule runs and the output lists, described above, with associated scheduling consultation. It does not include additional educational consulting nor keypunching services, which are done at standard rates. A simulation schedule is priced at about half the standard schedule contract.

Successful implementation of Variable Modular Scheduling sometimes requires considerable restructuring of plant and personnel; for example,

Figure 2. Example of a Student's Schedule

Sample Student Schedule
with a Variable Modular Schedule

		DAY A	DAY B	DAY C	DAY D	DAY E
8:00	1	US Hist. (Presentation)	Art (Presentation)	US Hist. (Presentation)	Algebra	US Hist. (Presentation)
8:20	2	↓	↓	↓	↓	↓
8:40	3				↓	
9:00	4					
9:20	5	Algebra		Algebra		Algebra
9:40	6	↓		↓		↓
10:00	7	PE		PE		PE
10:20	8	↓		↓		↓
10:40	9	↓	English	↓	English	↓
11:00	10	Lunch	↓	Lunch	↓	Lunch
11:20	11	↓	Lunch	↓	Lunch	↓
11:40	12		↓	English	↓	
12:00	13		French	↓		
12:20	14		↓	↓		
12:40	15				US Hist. (Discussion)	
1:00	16				↓	
1:20	17	Art (Lab)	PE		↓	
1:40	18	↓				
2:00	19	↓			PE	
2:20	20	↓	French	French		French
2:40	21	↓	↓	↓		↓
3:00						

(Coombs, et al, 1971, p. 33)

the development and staffing of resource centers, provision for teacher offices, and modifications enabling such facilities as cafeterias, libraries, and gymnasiums to remain open throughout the day. The hiring of paraprofessionals is sometimes necessary. The cost for these and other changes depends largely on existing school facilities--for example, whether or not the school already has rooms readily adaptable to large-group instruction--and the extent of educational innovation accompanying the schedule. Some schools seem to accomplish the changes with little additional outlay by simply reshuffling personnel and facilities. There are some savings that can be realized from the adoption of Variable Modular Scheduling. See, for example, the documentation of savings on substitute teacher salaries in the section on Oceana High School in Appendix A.

Procedures for Using Product

Learner Activities

Typically, before a student enters a school with Variable Modular Scheduling for the first time, he is given an orientation session to help prepare him for the new schedules. Students then have the opportunity to make course requests; this information becomes part of the input that the schools are required to prepare. Once in the system, students, to varying degrees depending on how the schedule is implemented, are given responsibility for their own learning; unscheduled time becomes independent study time for each student. Each student follows a schedule designed uniquely for him. While he is responsible for following his schedule, schools usually assume he needs some guidance and direction at crucial decision points.

Teacher (School Personnel) Activities

The implementation of a variable modular schedule is a very complex and demanding task that requires the cooperation of the whole school staff to really make it go. The school principal, then, is the main target of Variable Modular Scheduling promotional efforts. Although sometimes the initiative for change has come from below--via a school staff working out the ideas, petitioning the administration, and forcing the issue over administrative lethargy--by far the most significant initial interest has come from principals or vice-principals. Furthermore, if there is not a good working relationship with the principal and a lot of leadership on

his part, variable scheduling runs into considerable difficulties. The administrator plays the key role, whether he designs the plans himself or uses Variable Modular Scheduling as a vehicle to coordinate the results of his staff's decisions about how they want to do things. The support of the school superintendent can also be crucial because of the parent and community resistance that has plagued some variable scheduling efforts.

As noted earlier, school personnel are responsible for: setting timelines; compiling and transcribing input data (i.e., time periods, course structures, course assignments); preparing input data cards; and suggesting modifications in master schedules. They are also responsible for preparing the community and the parents before Variable Modular Scheduling is implemented and for helping students, modifying the master schedule and interacting with the community after the final master schedule is first implemented.

In-service training (i.e., consultation) is available from Educational Coordinates. In addition, general conferences, workshops, and seminars are held periodically throughout the country to help potential users of Variable Modular Scheduling.

Provisions for Parent/Community Involvement

While the development and implementation of a master schedule is not dependent upon parent/community involvement, the developers stress that parents and the community must be prepared for Variable Modular Scheduling. Some of the biggest problems have involved dissatisfied parents who felt their children were not receiving enough direction and supervision in school. The developers pointed out that, while some of the parents' complaints were quite justified, often their dissatisfaction resulted from misunderstandings that could have been prevented through proper orientation and continual school/parent interaction.

Special Physical Facilities or Equipment

Variable Modular Scheduling does not necessarily require renovation of an existing school, as the need for restructuring of plant and personnel might imply. What is required is a reallocation of existing resources. The developers have pointed out that Variable Modular Scheduling often allows more efficient use of existing facilities, such as auditoriums, libraries, and gymnasiums. What is most necessary is that unscheduled space be available to accommodate the approximately 35 percent of the enrollment on unscheduled time throughout the day.

Recommended Assessment Techniques for Users

No specific instruments for assessing the effectiveness of Variable Modular Scheduling, other than being responsive to the needs of and changes in the total school organization, are recommended by the developers.

ORIGINS

Key Personnel

The Stanford School Scheduling Project

The Stanford School Scheduling System was developed from 1960 to 1968 at Stanford University under the direction of educators, Robert N. Bush and Dwight W. Allen, and industrial engineer, Robert V. Oakford. The senior member, Dr. Robert N. Bush, was a full professor in the School of Education. His basic interest was in teacher education, and he was a strong proponent of the position that the Stanford School of Education should remain an active center for training teachers, as opposed to concentration on university level theoretical educational research. He had done a great deal of work with secondary school teacher education and related high school curriculum. Dwight W. Allen received his doctorate in education in 1959, working under Bush. He was a driving motivational force behind the project, supported by Bush's own ideas, experience, and tempering influence. Allen was an associate professor in the School of Education during most of the development period. Robert V. Oakford was a full professor of industrial engineering at Stanford at the time of the project. He received his B.A. from Stanford in 1940 and returned there to receive an M.S. in mathematics in 1956. In the interim he had wide experience in industry in both engineering and management and also did classified work for the U. S. Government. His research activities centered on engineering economy and capital budgeting theory and on both theory and application of computers in university administration. He was instrumental in the creation of the special Stanford computer language, SUBALGOL, written to be able to translate the original Burroughs computer language used by the Stanford scientific community (BALGOL) for use with a new IBM 7090 computer.

Many others contributed in major ways. The descriptive brochure on the Stanford School Scheduling System gives the following names of important contributors to the development effort in addition to the three directors

noted above: Programmers--Lynne A. Chatterton (chief programmer), Verne Stevenson, James Wilson, Stephen Brophy, J. R. Hamilton, John Hauser, and Arturo Salazar. Consultants in constructing schedules and working with schools--James Smith, James Olivero, Arthur Coombs, Robert Kessler, Donald DeLay, and Ray Johnson.

Educational Coordinates

The original founders of Educational Coordinates, incorporated in 1967, were Dwight Allen and Robert Oakford. They gave the leadership of the organization to three members of the Stanford School Scheduling System staff: Arthur Coombs, Robert Kessler, and Lynne A. Chatterton. Arthur Coombs is Chairman of the Board and based in the Sunnyvale, California, headquarters. He received his M.S. in educational administration from the University of Utah and came to Stanford as a graduate student in 1965, after working two years as Principal of Roy W. Martin Junior High School in Las Vegas, Nevada. He is an advanced candidate for a Ph.D. in education at Stanford. Robert Kessler is President and a Director of Educational Coordinates and is based in the Boston office. Dr. Kessler was a graduate student at Stanford from 1965 to 1968, where he received his Doctor of Education degree. Miss Lynn A. Chatterton, the chief programmer of the original system components, is now Vice President and a Director of Educational Coordinates, and she directs continuing improvements in the Educational Coordinates' scheduling system. She received her B.S. degree in statistics from Stanford, where she worked with Professor Oakford as an undergraduate, and shortly thereafter became one of the few full-time employees of the Stanford School Scheduling System project.

Other key Educational Coordinates personnel include: Ray Talbert, Director of the Northwest office in Salem, Oregon, Toshio Sato, Director of the Sunnyvale office, and Robert Madgic, Curriculum Coordinator in Sunnyvale. Oakford and Allen, who are now professor and dean at Stanford University and the University of Massachusetts, respectively, are on the Board of Directors of Educational Coordinates. Oakford is still in charge of servicing ongoing requests for the Stanford School Scheduling System, which still may be purchased at nominal cost from Stanford University.

Sources of Ideas for Product

Trends of the Times

Throughout the 1950's there was a growing movement among educators for both curriculum reform and individualizing instruction. To replace the uniformity of teaching methods and courses tied closely to textbooks and grade levels, many curriculum development projects were initiated and systems analysis approaches made to attempt to define educational objectives and analyze alternatives. The questions that were being asked revolved around how best to prepare the coming generation of students for the changing world they would be inheriting in the second half of the century.

Technological Prerequisites

It was also in the mid-1950's that relatively high-speed, economically feasible digital computers began to appear in growing numbers in universities, government, and business. In public school districts, electronic data processing was slowly being applied to routine clerical and accounting functions. In 1958, with the passage of the National Defense Education Act (NDEA), a large influx of federal money was available to state education departments on a matching basis in support of educational data processing. The California State Department of Education pioneered in large-scale computer applications, initiating a "Pilot Project in Educational Data Processing" in 1960 in the Richmond School District which became the nucleus of a master plan for developing regional computer centers throughout the state. Growing interest, fueled also by the post-Sputnik emphasis on science, mathematics, and technology in education, made other funding available. The Ford Foundation, for example, made numerous large computer-related grants over the next few years to, among others, New England Educational Data Systems (NEEDS), Iowa State University, MIT, and Educational Testing Service, as well as Stanford. In 1958 the Ford Foundation also established Educational Facilities Laboratories, Inc., a nonprofit corporation to help schools and colleges experiment with improved designs for physical facilities.

In 1962 the growing activity in the field led to the formation by educators of the Association for Educational Data Systems (AEDS), a professional organization at the national level. Many similar state-level associations were founded. A professional journal devoted entirely to

educational data processing appeared in 1964. In the first issue of the Journal of Educational Data Processing the lead editorial expressed the opinion that the previous two years had brought greater growth and progress in the field than all past years put together.

Relevant Research

The variable modular scheduling movement traces its beginnings to the National Association of Secondary School Principals' comprehensive Staff Utilization Studies made over ten years ago and described in Dr. J. Lloyd Trump's 1961 book, Focus on Change: Guide to Better Schools (I/D/E/A, 1968). These educational recommendations focused heavily on varied patterns of instruction (e.g., small groups, large groups, team teaching, tutorial and independent study, etc.) and asked what staffing arrangements, time patterns, and physical facilities would best support them. From these beginnings, secondary school educators began to question existing school organizational structures of all kinds--the schedule and the physical facilities, as well as the curriculum itself. They began to ask serious questions about revising the priorities implied in what they considered forcing courses and students into organizational structures rather than fitting organizational patterns to educational goals.

Research into the possibilities of computer-assisted school scheduling began in the late 1950's and was devoted almost entirely to "load" programs--student assignment to classes in an already existing schedule. This is a complicated enough procedure of getting a student into a section of each course he has requested while making sure that each section meets at a different time. It also involves balancing section sizes and allowing for room capacities. Few investigators considered the intricacies of programming the master schedule itself worth tackling, although A. G. Holzman at the University of Pittsburgh was one who did begin several years of theoretical research on the master scheduling problem. (The magnitude of the mathematical problem has been expressed by the calculation that with an 80-period week and 1,800 students it would take a computer 25 years at one million operations per second to systematically consider all the possible schedule alternatives.)

One of the earliest student assignment programs was developed by James Blakesley in about 1956 at Purdue University and later successfully applied at many universities. Shortly thereafter IBM developed its CLASS system

(Class Load and Student Scheduling), based on some of the early Purdue work and first used in about 1960. G. Ernest Anderson, Jr., of the New England School Development Council worked out a secondary school student assignment program, which began to be used in about 1962. The California Richmond High School District launched the ambitiously-named SOCRATES (Scheduling of Classes Realized Automatically Through Effortless Systemization) in 1964. By the mid-60's several such effective programs were in wide use.

Similar Products

The only other (i.e., other than the Stanford School Scheduling System) practical and similar method to build school master schedules was developed by Robert E. Holz at the Massachusetts Institute of Technology, beginning in 1961. With a grant from the Educational Facilities Laboratories (sponsored by the Ford Foundation) and with computer time donated by IBM, the initial programs were written and tested during 1962; it was called the Generalized Academic Simulation Program. A second version was completed in March 1964 after revisions based on field tests at three secondary schools and the simulation planning of a new junior college. In 1965, 25 high schools around the country were scheduled with the Generalized Academic Simulation Program. Holz described his approach as a "pragmatic" one, closely simulating the clerical aspects of manual scheduling but using the computer's speed and accuracy to try out a multitude of alternatives and test the feasibility of proposed schedule innovations. It required several computer runs (5-15) and relied on close human scheduler interaction with the computer in analyzing the output from the successive computer runs and so evolving a satisfactory master schedule (Holz, 1964).

Oakford's work at Stanford took a different direction. His solution allowed for more preprogramming decision-making by the computer while assuming more detailed, accurate, and sequential definition of the initial scheduler input data, and it could therefore generate a successful schedule in three computer runs or less. Both the Generalized Academic Simulation Program and the Stanford School Scheduling System were heuristic algorithms--that is, based on a logical trial and error procedure, not a mathematical solution. Both generated the schedule in two parts, first the timetable and then the assignment of resources. The basic requirements were the same to meet the same educational objectives. However, according to those using

methods based on the Stanford School Scheduling System, it could serve more schools for less money because of fewer demands on costly computer time. The Generalized Academic Simulation Program, modified and updated, is still being used, but seemingly on a limited and declining scale. It is apparently useful as a research tool in planning school facilities and can be successfully used for schedule-building by school districts which have the human scheduler expertise required.

Evolution of Ideas for Product

The educational philosophy that emerged from the early collaboration at Stanford University of Bush, Allen, and Oakford is described by Bush and Allen in their book, A New Design for High School Education--Assuming a Flexible Schedule, published in 1964. In the late 1950's, based on the model suggested by Trump, Bush and Allen began to explore the use of time in the curriculum to bring instructional patterns into better relation to both subject matter and student needs. Inevitably, as other educators had, they ran into the obstacle known as the school scheduling problem. The answer from school administrators to many suggestions for educational change was, "We'd like to do it, but there's no way we can schedule it."

Allen approached Oakford of the Stanford Industrial Engineering Department to ask if the computer could help. Oakford's reply was a question--Could Allen furnish him with a detailed description of the logic of school schedule-building? Allen could not, and at that point the investigation began with the question of how school scheduling might be systematized into some set of rules that the computer could handle. It was Allen who got Oakford interested in the theoretical computer problem of building a school schedule containing multiple organizational structures. Allen's motive was educational innovation, and he was casting about for some existing computer capabilities that might be answers to his educational goals. But while the computer technology existed, the programming capabilities did not, and this original side issue became a major thrust of the secondary education research effort at Stanford over the next several years.

Some of Professor Oakford's early theoretical issues are described in his 1961 paper in the Journal of Secondary Education. In it he describes how "the principles of constructing school schedules are not sufficiently

understood, if indeed they exist" to define the strategy to be executed by a computer program. He expresses optimism, however, on the basis that computers can be programmed to make logical decisions and perform arithmetic operations of the same magnitude and complexity as those involved in a school schedule. But because the large mass of data and enormous number of computations necessary to schedule a school of 2,000 students would be extremely costly in terms of computer time, he recommended a strategy that would interrupt the computer as little as possible in its quantified decision-making for the human policy decisions that would have to be made. This implied that judgment decisions by the school must be clearly and precisely defined at the outset and translatable in sufficient detail to program the computer for executing its logical operations. He planned to proceed, also, in a one-step approach wherein teacher, room, and student assignments were made at the same time as the timetable for class meetings (master schedule) constructed. Oakford's theoretical orientation eventually led to a scheduling algorithm allowing for more preprogramming decision-making in the Stanford School Scheduling System than did the comparable Generalized Academic Simulation Program developed at MIT at the same time. On the other hand, Oakford's one-step approach proved impracticable, and the Stanford School Scheduling System builds the master schedule with teachers and rooms in one step and assigns students in a second step.

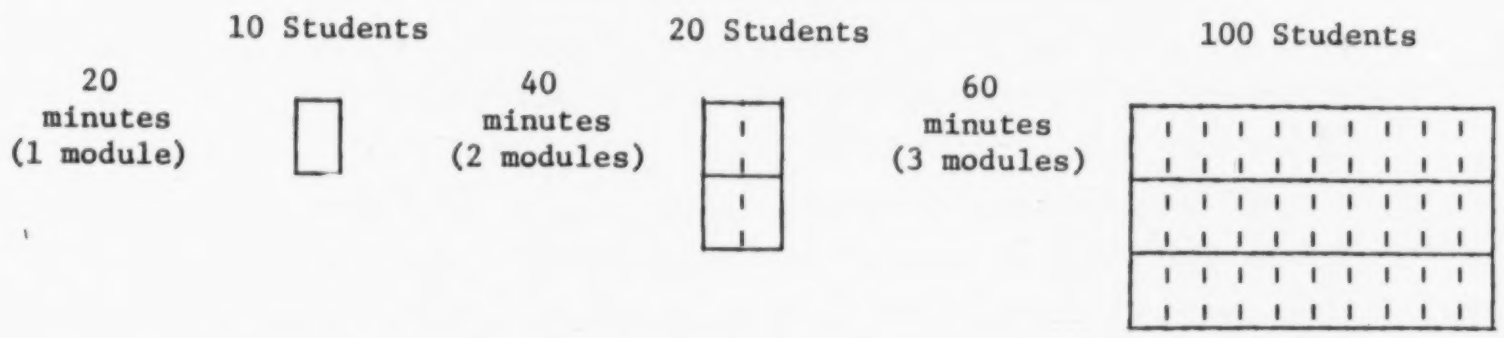
In the meantime, Bush and Allen formulated the beginnings of their "new design" for the high school (defined as grades 7-12) of the future. Their first basic assumption was that the democratic ideal of a liberal education for all should be preserved within the framework of the comprehensive public high school. The second was that the educational changes necessary for this in an increasingly complex society were hindered not so much by disagreement on what ought to be done as by lack of the technical and organizational know-how to implement it. They broadly defined these educational reforms in terms of a change in emphasis from a concern with quantity (all students in school for a fixed number of years under a standard system of units and credits based on time) to the goal of quality (excellence in providing a liberal, and the beginnings of a specialized, education based on individual student needs). They then narrowed their own focus to taking away the fetters which they saw binding much-needed experimentation to this end.

Their motto, they said, was "take away the limitations." Many promising innovations--in curriculum, in technological aids such as television, teaching machines, and audiovisual aids, and in teaching techniques--simply could not be fitted into the common high school program of six years of 36 weeks each of 55-minute daily periods of a rigid set of course requirements. Time, they said, was no way to measure what a student learned, and isolation of required courses and lack of sequencing discouraged continuity. "Columbus predictably sails on schedule in 5th, 8th, and 11th grade required courses in American history without any attempt made to build upon previous learning [Bush and Allen, 1964, p. 10]."

Beginning by conceptualizing the school curriculum as a two-dimensional area to be scheduled, with one dimension being number of students (class size) and the other dimension being time, they developed a model-building method of curriculum planning. (See Figure 3.)

Figure 3

The Modular Building Block Approach



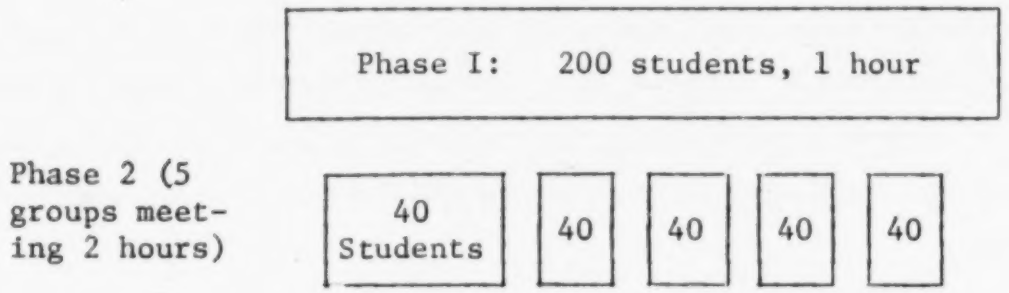
From this modular building-block approach, evolved modular scheduling based on variable course structures. (See Figure 4.)

Figure 4

Sample Multi-Phased Course Structure
(Based on above 20-minute minimum time periods
and 10-student minimum class group)

Total time during week: 4 hours, 40 minutes

Total student enrollment: 200



Funding for Product Development

Stanford School Scheduling Project

Specific funding for the Stanford School Scheduling System was by Ford Foundation and U. S. Office of Education grants, but additional major indirect support came from other Stanford School of Education projects and from government funding of related projects of the school districts which participated in development. The Ford Foundation made several grants in support of a comprehensive study of secondary education at Stanford in the late 1950's and early 1960's, including but not limited to the flexible scheduling aspect. Other emphases were staff utilization, planning of physical facilities, and various curriculum innovation studies.

The "High School Flexible Scheduling and Curriculum Study" was officially launched at the Stanford School of Education in the spring of 1960. In the five year period, 1960-1965, with Ford Foundation support, the Stanford School Scheduling System was developed from its theoretical beginnings to the

operational stage (1963) and into two years of field testing in cooperating high schools. In 1965 the development effort continued, now known as the Stanford School Scheduling Project, with major support from a U. S. Office of Education grant to explore its potential for vocational education.

Conferences and other forms of communication among interested educators were subsidized by various groups. For example, in 1965 the Association for Educational Data Systems joined with the Stanford School of Education to sponsor a large invitational conference on the role of computers in American education, including modular scheduling. Stanford offered summer workshops on the subject of variable scheduling and related innovations and sponsored conferences bringing together nationally recognized experts in pertinent educational theory.

The figure given by the developers for the total research effort is approximately $1.5 million from federal, private foundation, and university funds. Three grants from the Fund for the Advancement of Education of the Ford Foundation totaled $213,000 over the seven year period. Two grants from the U. S. Office of Education came to $944,000 over the last three years (1965-1968) for investigation of "Flexibility for Vocational Education through Computer Scheduling." The developers emphasize that the $1.5 million total is a conservative figure that does not by any means represent the total cost of development. They also emphasize that the actual computer programming costs were only a fraction of the total (under $200,000). In addition to the above-mentioned support from related projects in the School of Education, there was a large nexus of educational support represented by the contribution of the schools and other interested groups.

Except for the first four pilot schools, all the participating schools were charged for the scheduling service each year. They paid in the range of $1.00 per student, based on the comparable cost to hand-schedule a traditional school. With the average of about 1,000 students per school, this probably brought in something over $200,000. Furthermore, there was hardly a single school that participated without federal monies in one form or another, most often through Title I or Title III of the Elementary and Secondary Education Act (ESEA). In fact, as the project gained publicity, it was not always apparent how much of a school's interest was in educational change and how much was in using participation in the scheduling project as a

lever to attract more government resources. In any case, the schools received numerous grants to work on research designs related to modular scheduling or specific problems arising from it.

Variable Modular Scheduling

Costs for development of Variable Modular Scheduling (i.e., for the modifications made in the Stanford School Scheduling System) were figured into the costs charged the schools by Educational Coordinates. However, the actual amount of development money spent by Educational Coordinates is unknown.

PRODUCT DEVELOPMENT

Management and Organization

The Stanford School Scheduling Project

The Stanford School Scheduling System was developed entirely under the auspices of Stanford University, Palo Alto, California. The development of this system is an example of the kind of interdepartmental cooperation and pooling of resources that is possible in large university supported projects. The study originated in the School of Education, but the computer program design and development was done in the Department of Industrial Engineering and utilized the resources of the Stanford Computation Center. Furthermore, related projects in the School of Education contributed substantially. For example, the scheduling project inevitably touched on the entire organizational structure of the high school, both staff and facilities. There was a large School Planning Laboratory at Stanford under the direction of Professor James D. MacConnell. This served as a regional center of Educational Facilities Laboratories, Inc., established by the Ford Foundation to assist in planning for new school design. Obvious common interests brought this "bricks and mortar" group and its resources into close cooperation with the Stanford School Scheduling System group. An internship program sponsored by the National Association of Secondary School Principals (NASSP) and other educational administration activities directed by Professor Normal Boyan provided similar support based on overlapping interests. Another large effort at Stanford, under a grant from the Kettering Foundation of Dayton, Ohio, was "micro-teaching," an experimental teacher training tool involving the

videotaping of various teaching techniques, trying out a single skill or concept at a time. Professor Bush was the project director, with a great deal of interest in it, and, again, it fit in with variable scheduling in the areas of staff training and innovations in instructional modes and curriculum. In addition, close to 100 schools participated in the Stanford School Scheduling System development over a five year period. Some had much more impact than others, but the whole concept of variable modular scheduling evolved in the partnership between the schools and the Stanford developers. There was constant interchange of both ideas and personnel.

Throughout the duration of the project there were two separate but interrelated lines of development:

- The technical side, represented by Professor Oakford and supporting computer programmers and data processors, focusing on the actual computer scheduling programs.

- The educational side, represented by Bush, Allen, and others in the School of Education, focusing on the evolution of new school instructional practices and curriculum patterns.

There were occasional organizational and human dimension problems that arose between the two groups at various times as the project grew--which side was the more important, how to define priorities, and so on. As one staff member expressed it, this was like saying, "head, I have no need for thee, hand," regardless of which side was playing head or supporting hand at any one time. But apparently a sort of shared missionary zeal to get the system working sufficed to overcome such difficulties.

For the first four years the project staff was never centrally located. By 1962 Professor Oakford had begun teaching some computer courses for engineers in what was just beginning to be called the Computer Science Department, at that time a small offshoot of the Mathematics Department. The programming and data processing were done out of his office there and a small amount of additional space. On the education side, the research assistants worked out of their regular assigned study carrels in the Education Building. The actual computer work was, of course, done at the central Stanford computer facilities (what became the Stanford Computation Center). By 1965 Stanford had bought a large building off the campus to absorb the

overflow from various university research projects. The first group to move in was a physics project (laser development) and the second was the School Scheduling Project, which had grown to considerable size. There, for the first time, all the project activities (educational and technical) were brought together, including the data processing, with daily courier service to the campus computer facilities. This remained the headquarters until the project's end in 1968.

Before 1963 there was no real identifiable project staff except for Bush, Allen, Oakford, and Lynne Chatterton, who began working full time as a programmer in 1962. In 1963 when the big push came to get the system operational, there were two additional graduate student programmers and a data processing helper. Don DeLay and two other research assistant school counsultants worked with the four pilot schools that year. In 1964 when the schedules were built for 26 schools, there were the same three programmers, three programming assistants, and five school consultants, plus a small data processing staff. In 1965, when Coombs and Kessler joined the staff as school consultants, there were still only five consultants altogether; there were four programmers. In 1966 and 1967 the staff was at its peak size. Lynne Chatterton was Supervisor of Programming and Production, with a staff of 10-12, and Don DeLay was Director of School Scheduling Services with a staff of 7-11. In those two years Coombs and Kessler also acted as Conference Coordinators for the workshops and feedback conferences that were going on, and had one full-time assistant for that. The actual project staff was never large--"always smaller than it should have been"--and especially in the early period the staff put in unbelievably long hours, "because it had to get done."

Thus, in addition to the three co-directors, the project staff consisted almost entirely of graduate students working as either research assistant school liaison consultants or computer programmers, plus a small data processing and production staff made up largely of Stanford students working part time. However, it should be emphasized that the graduate student school consultants on the actual project staff were almost all experienced young educators. Bush and Allen drew to the Stanford School of Education during these years a cadre of school administrators and teachers interested in the educational possibilities of modular scheduling. The way Arthur Coombs

came in will illustrate the kind of thing that happened. It is also an illustration of the way many of the participating schools came in. Art Coombs was the principal of Roy W. Martin Junior High School, Las Vegas, Nevada, when they first began to experiment with things like team teaching and small group-large group course structures, based on some of Trump's ideas. Coombs says the major influence was Trump's book, Focus on Change, not the work coming out of Stanford. They began in 1962-63 with some small-scale block scheduling in the science department to allow course flexibility and released time for independent study for certain students. The following year the school district had set aside some funds for innovation and solicited proposals from the schools. In the meantime, Dwight Allen had been invited to speak to the school administrators, and many principals had been inspired to think along the lines of the kinds of innovation he was promoting. The staff at Roy W. Martin Junior High had a head start from the previous year's experience and had already been thinking about how to expand on it. Out of perhaps 15 proposals, theirs and one other school's were accepted. Dwight Allen was one of the proposal reviewers selected by the district and, of course, brought to it a pitch for the benefits of the Stanford computer scheduling assistance and the opportunity to tie in with other schools and university educators working along the same lines. Roy W. Martin subsequently became the first junior high school to participate in the Stanford School Scheduling System project; along with the other Las Vegas school, it was one of the 26 schools in the second year of operation.

Art Coombs implemented the schedule at the school that year and during the summer (1964) while the schedule was being built had a chance to talk to people from the first four schools which had pioneered the previous year. He also attended one of the summer workshop courses at Stanford. The following year he was admitted to Stanford's doctoral program and immediately began working as one of the graduate student school consultants. On the programming side, according to Lynne Chatterton, the motivation was the "fantastic challenge" of working in an area that was completely new. In contrast to the usual programming procedure of looking for alternate ways to program something already done, this was a meaty problem that had never been attacked before. Most of the school consultants, therefore, had been

involved in implementing the educational ideas, and sometimes the scheduling system itself, in the field before coming to Stanford to work on the project staff. They were dedicated to the ideas behind the project and committed to make the technology work to support them.

The picture that emerges of the relationships among Bush, Allen, and Oakford is one of an educational innovator-organizer-salesman (Allen), sustained by an older, experienced mentor (Bush), with Oakford not only contributing the theoretical and technological breakthroughs but also playing a key role in the definition and refinement of the whole concept. When ideas passed the brainstorming state, Bush's molding, modifying, perfecting influence polished them. Bush was also the respected older scholar supporting Allen, the brash young innovator, among outside educators and within the university structure. Bush's presence on the development team overcame resistances to change by the weight of his experience and reputation and lent prestige to the whole project.

Once hooked on the idea, Oakford searched out on his own many of the as yet undefined actualities of school scheduling practices, and he was the one who made the judgments in the all-important area between educational plans and technical possibilities. He was a key sounding board and was the dominant influence in getting the educators to make the kinds of precise definitions necessary to proceed with a scheduling system.

The day-by-day administrative decision-making, including money allocations, was largely handled by Allen. Allen was evidently the type of administrator who was forceful in seeing that things got done and infinitely uninterested in carefully accounting for how they were done or paid for. However, he worked well with and was supported by the administrator in the Dean's Office who was responsible for disbursement and audit of the many different project funds in the School of Education. So, while available money for the scheduling project at the right times and places was a constant problem, it was surmounted by a lending and borrowing process that left commitments fulfilled and money accounted for in the end, while juggled in the meantime according to needs.

The project's organizational structure seems to have been similarly informal. Meetings of all kinds were the main vehicle of communication, ranging from brainstorming sessions to the formal conferences that were

held each year to get feedback from the participating schools. There was little formalization otherwise of information channels. Lynne Chatterton and other key assistants became the repositories of much of the information gathered informally each year through letters from schools, telephone calls, interoffice notes, and so on, and the following year's priorities were sifted out in meetings into definite decisions.

Educational Coordinates

According to Educational Coordinates personnel, the company was basically formed in order to continue servicing the schools being scheduled and not let drop the educational philosophy behind the Stanford project. Discussions about how best to do this began in early 1967 among Oakford, Allen, Chatterton, Coombs, and Kessler, and with the advice of a lawyer friend of Allen's (Jack Teeters, still Educational Coordinates' general counsel and a stockholder) and a Stanford Business School associate. Ideas ranged from a university connection to a nonprofit organization to a profit-oriented company. The latter prevailed. The reasons given were the uncertainties of stable funding sources under a nonprofit setup and the philosophy that if the idea was really viable the schools should be able to pick up the true costs, with a profit margin sufficient to continue development. Educational Coordinates was incorporated in February 1967, but did not commence business operations until December.

With Oakford and Allen on the Board of Directors, but basically in the background, Coombs and Kessler took on the major organizational and management responsibilities, while Lynne Chatterton took on the technical responsibilities. At the fall 1967 feedback conference schools were told that the project was ending at Stanford, and in December schools were notified by telephone that Educational Coordinates had been formed to continue the service.

The year 1968 was very transitional, with personnel splitting time between Educational Coordinates and Stanford. By early 1969, when Robert Kessler opened an Educational Coordinates office in Boston, the second major organizational decision had been made--to try to promote the system in a major way on a national basis. The described alternative would have been for Coombs and Kessler to have maintained their research orientation connected to the university and run Educational Coordinates as a consultant-

like sideline operation, continuing to comfortably service the existing schools with Educational Coordinates' established expertise. In other words, they might have kept it small and local, but the decision to attempt a national effort was again expressed as due to the desire to spread the concepts--"more people ought to be doing it."

In 1968 the project was phased out at Stanford, and Educational Coordinates did the actual scheduling for the schools that contracted with them, as well as the schools participating in that final year of the Stanford vocational education project. The support of Stanford was essential to Educational Coordinates' launching, and Educational Coordinates personnel finished up some of Stanford's obligations. For example, Lynne Chatterton spent the summer of 1968 almost entirely working on the final documentation of the Stanford School Scheduling System. Educational Coordinates personnel largely did the "debugging" of the FORTRAN IV translation of the computer programs to get them operational in the 1968-69 school year and transmitted the information to both Stanford and the University of Iowa. Stanford computer facilities were used and paid for by Educational Coordinates for their schools. The programmers and production personnel moved to Educational Coordinates, but they "wore two hats," partly paid by Stanford, partly by Educational Coordinates. Five Stanford graduate student school consultants were hired by Educational Coordinates on a per school commission basis.

The avoidance of any question of conflict of interest was the main reason that the Stanford School of Education auditor was a member of Educational Coordinates' Board of Directors during the first two years. He was familiar with the whole project--the grants, the equipment, and personnel--and could head off any potential problems. "If there was any hint of a question, we did it some other way."

Educational Coordinates is still a small organization. In 1971 it has approximately 30 full time staff members altogether at three offices--the main office in Sunnyvale, California; the Boston office headed by President, Robert Kessler; and a Northwest office in Salem, Oregon, opened in late 1970 under the direction of Ray Talbert. About ten educational consultants and five technical people make up the professional level staff, and the remainder are production, administrative, and clerical personnel. Additional data processing and production personnel are employed for the peak scheduling season from April to September.

The company's principal activity is still school scheduling, both traditional and variable schedules; it also offers standard school data processing services. It is moving more and more into the area of instructional materials development, including films, under the direction of Curriculum Coordinator, Dr. Robert F. Madgic. There are some miscellaneous consulting services related to instructional methods, curriculum innovation, and school administrative and staffing practices; surveys or help in proposal preparation are also done for school districts.

A major activity is the conducting of local, regional, and national conferences, workshops, and seminars on educational innovation and aspects of computerized scheduling. There is a growing emphasis on in-service training. These conferences and seminars, attended mainly by school superintendents and principals, constitute the company's significant promotional and marketing effort. There are no full time marketing personnel as such.

Original Development Plan

As suggested in the section on Origins and in subsequent sections on Sources of Ideas for Product and Evolution of Ideas for Product, the original development plan, which was very generally specified, called for extensive exploratory work. Consequently, the exact nature of the product now called Variable Modular Scheduling, how it was to be developed and evaluated, and how it was to be implemented in the schools were to be determined on the basis of exploratory work and were not specified in the original development plan.

However, some things were clear from the beginning. The developers wanted to change the emphasis in education from a concern with quantity to a concern with quality. They knew that this would require a significant amount of interaction with the schools. Their product would always have this aim to change the emphasis, and the success of the product would be highly dependent on how it was used in the schools. They also knew that they would use a computer to help them develop their variable schedules. The system itself, however, would have to be determined through exploratory work. Thus, the original development plan was more a specification of general intent rather than a clear delineation of activities.

Modifications of Original Development Plan

The general intent of the developers was never significantly modified. As implied above, the exact nature of their product and how it was to be developed, evaluated, and implemented was constantly changing. Major changes in the technology and in the implementation of the product are discussed below as actual steps in development and diffusion.

Actual Procedures for Development

Development

The development of the Stanford School Scheduling System was a partnership between the Stanford development team and the participating schools. Although this report refers to the first year of operation in four schools as a "pilot test," the developers refer to these schools as their "pioneers." The term is significant. Those schools paid nothing for the scheduling, but when they agreed to participate there was also literally nothing tangible to assure them of getting a workable schedule. They ventured onto complete new territory, and the computer programs were written step by step along with them. One of the pioneer schools fell by the wayside the following year, and the partnerships with the approximately 100 schools over the next four years were beset with innumerable difficulties. But they provided the interchange between computer technology and educational practice that produced a viable system.

The developers do use the term "field testing" to describe the activities of the succeeding years, but this does not connote any systematic evaluation design for testing an identifiable entity at any one time. Rather, it was a continuous process of experimentation, with continuous modifications based on feedback each year. This was inevitable, since the main objective was to encourage educational innovation and design the enabling technology for that purpose. The solicitation of the feedback did proceed on a systematic basis, however, and a major decision along the way of development was to try to generalize the technology rather than to solve individual school problems most efficiently.

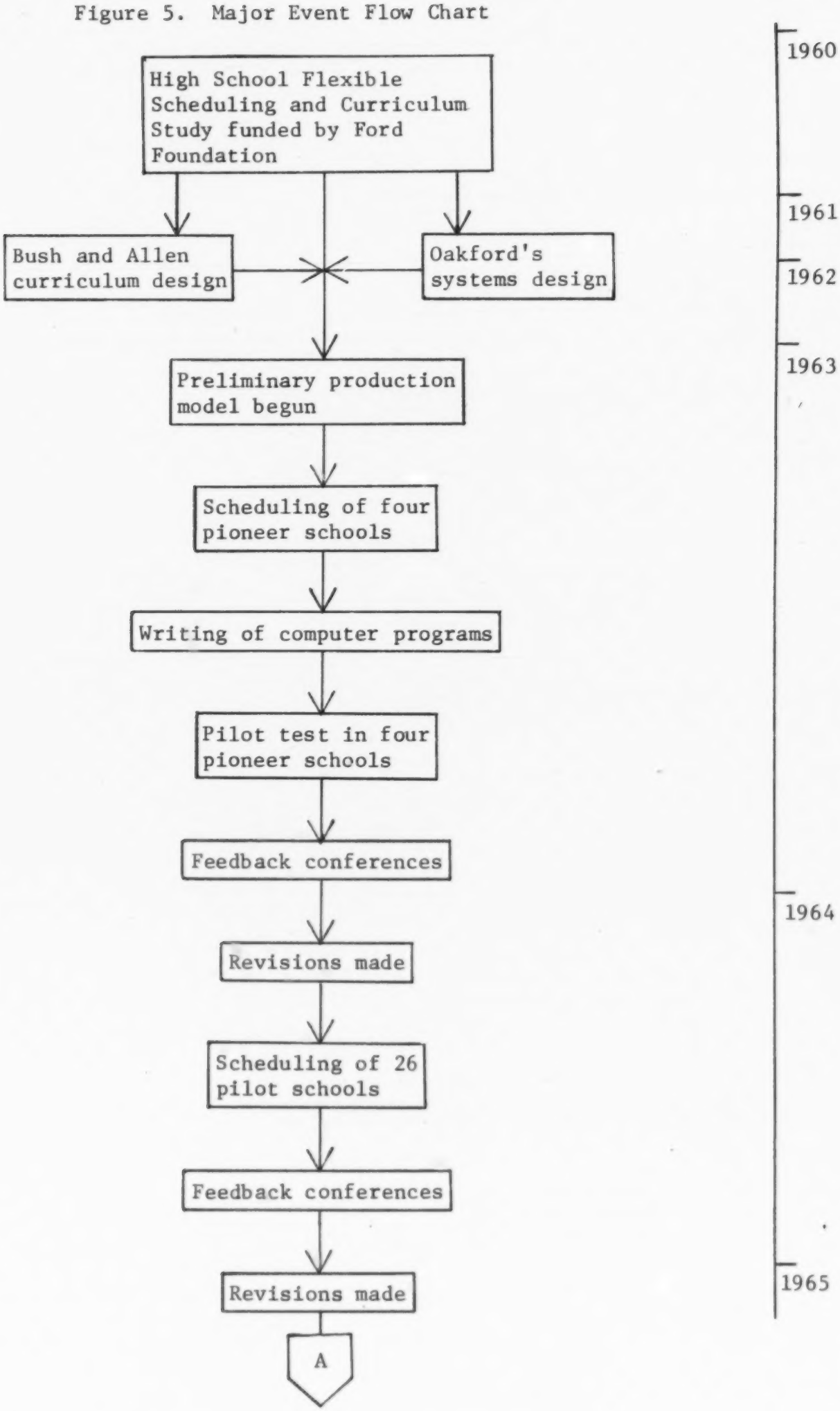
The flow chart on the following pages shows the major sequence of events during development. The discussion that follows will focus first on the events leading up to and including 1963 when the programs were actually

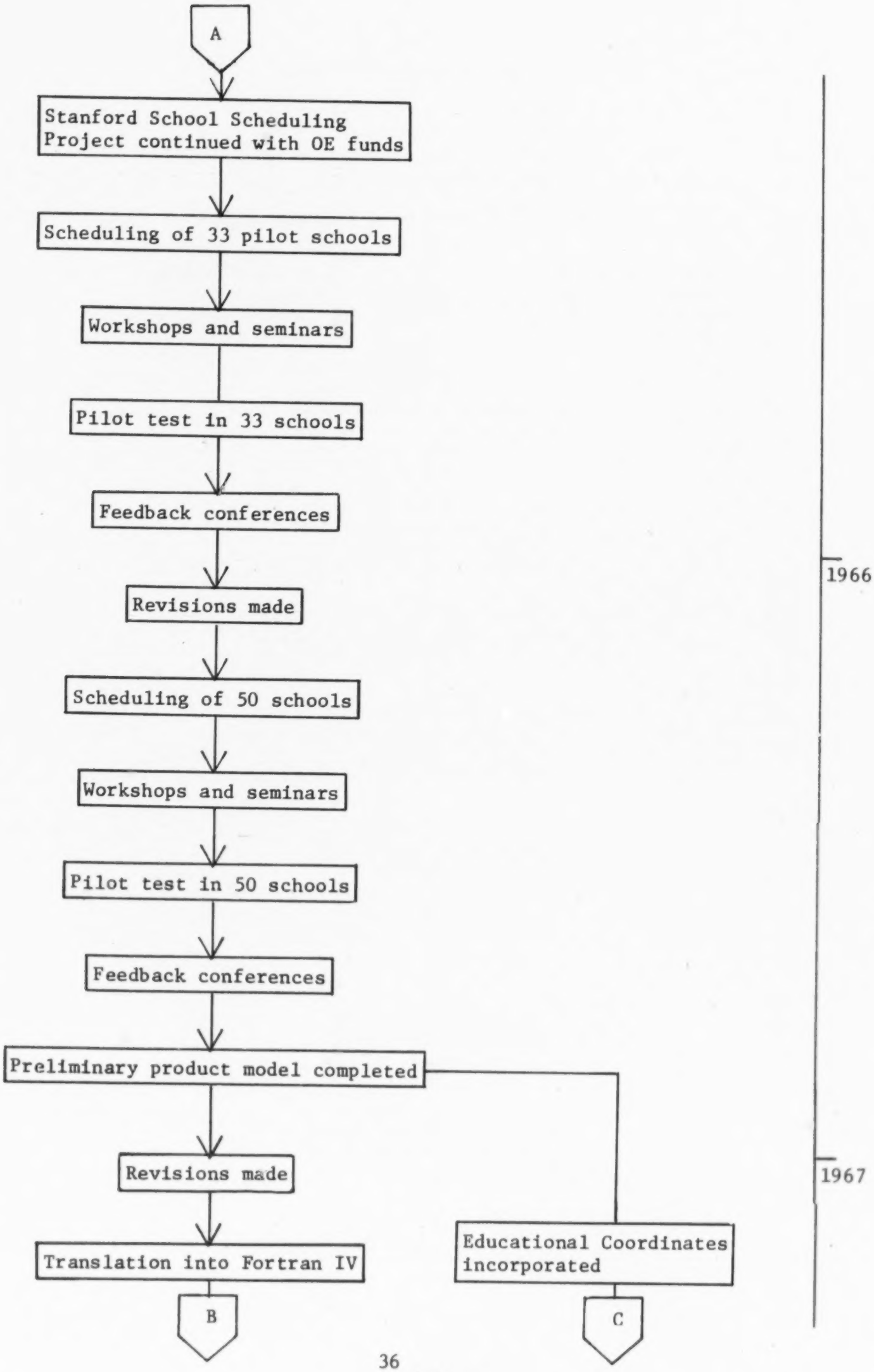
written and used to schedule the four pioneer schools. In understanding the description of this and the ensuing continuous development and formative evaluation, it will help to realize that the actual scheduling was done in the spring and summer, to be tried out in the schools beginning in September. When referring to any one year's scheduling (e.g., 1963), the implementation of it should be understood to take place in the school year beginning that fall (e.g., 1963-64). Also implied is that a school would have been formulating plans for the schedule any time from the previous fall through winter (e.g., 1962-63). On the flow chart the schools scheduled each year are shown by school year, indicating schedules in actual operation.

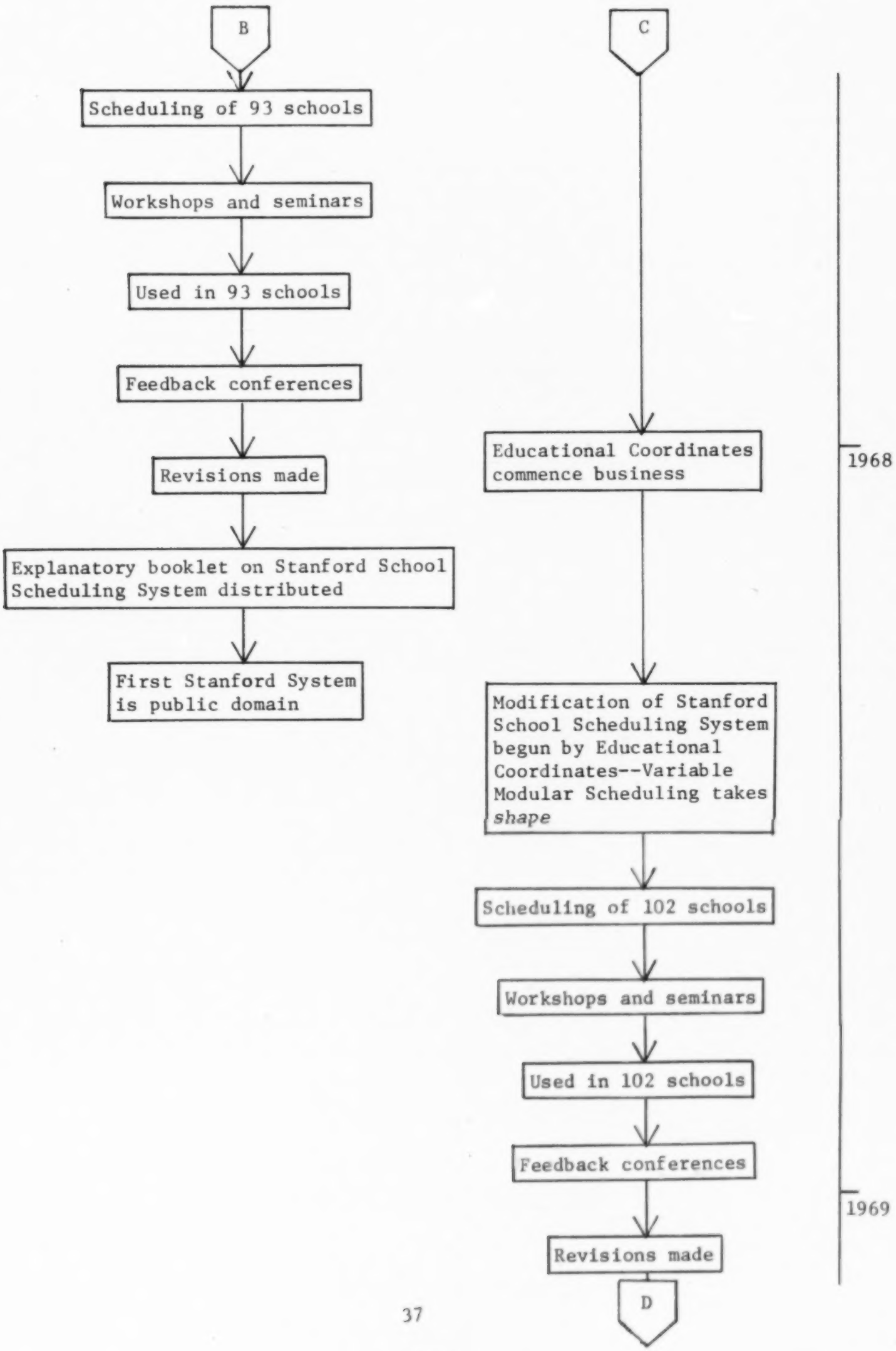
Groundwork. The early theoretical work done by Bush and Allen, on the one hand, and Oakford on the other, has been described in the section on Origins. During 1961 and 1962 a great deal of activity centered on attempting to define how schools were really scheduled and investigating existing computer approaches. Allen brought back information and stimulated discussion through his wide contacts with school people, but it was largely Oakford who made systematic sense out of this information. Oakford made literature searches, talked to school personnel and other educators on his own, and exchanged information with Holz at MIT, who was beginning to develop his Generalized Academic Simulation Program at the same time. He went out to see how school schedules were operating, asked questions about how administrators said they went about it, and gradually developed the understanding that enabled him to define a direction to go in.

The decision to go ahead with a computer scheduling system was influenced by the results of the previously mentioned feasibility pilot study done by Oakford during this period of initial research. Only after the field experimentation over the next three years did a clear picture emerge of the kinds of educational demands and/or restrictions that would be made by schools on a scheduling system. It then became possible to define the nature of the school scheduling problem as a "linear integer programming problem." A linear integer programming problem is a most complex computer problem. A solution involves so many variables, so many computer search patterns, that it is not economically feasible. The technical staff did try to adopt parts of the system to linear integer programming in 1966-67 but found it impracticable. "There is no computer big enough to store all the constraints."

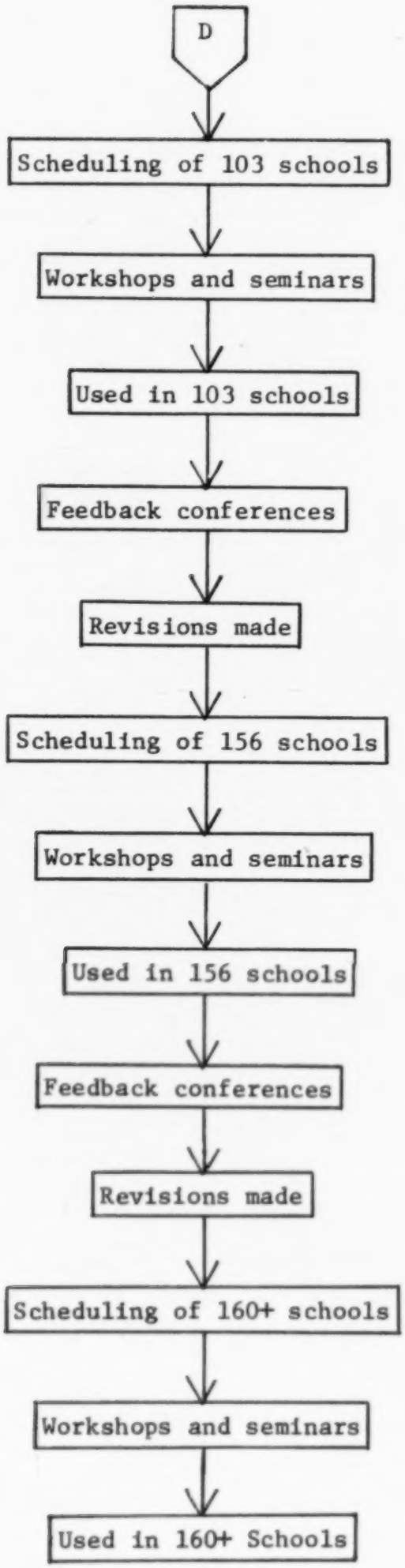
Figure 5. Major Event Flow Chart




A
Stanford School Scheduling Project continued with OE funds
Scheduling of 33 pilot schools
Workshops and seminars
Pilot test in 33 schools
Feedback conferences
Revisions made
Scheduling of 50 schools
Workshops and seminars
Pilot test in 50 schools
Feedback conferences
Preliminary product model completed
Revisions made
Translation into Fortran IV
B
Educational Coordinates incorporated
C
1966
1967


B
Scheduling of 93 schools
Workshops and seminars
Used in 93 schools
Feedback conferences
Revisions made
Explanatory booklet on Stanford School Scheduling System distributed
First Stanford System is public domain
C
Educational Coordinates commence business
Modification of Stanford School Scheduling System begun by Educational Coordinates--Variable Modular Scheduling takes *shape*
Scheduling of 102 schools
Workshops and seminars
Used in 102 schools
Feedback conferences
Revisions made
D
1968
1969

143


D
Scheduling of 103 schools
Workshops and seminars
Used in 103 schools
Feedback conferences
Revisions made
Scheduling of 156 schools
Workshops and seminars
Used in 156 schools
Feedback conferences
Revisions made
Scheduling of 160+ schools
Workshops and seminars
Used in 160+ Schools
1970
1971

By the summer of 1962 weekly meetings were being held at Stanford, attended by the project directors, Chatterton, and assorted interested professors and graduate students. The aim was to arrive at the practical approach to be taken to actually write computer programs to get the first four schools scheduled. These were brainstorming sessions, based on Oakford's theoretical groundwork--all kinds of approaches for building the schedule were considered. What emerged was Oakford's basic heuristic algorithm for generating the master schedule. The computer program written for it was named by Lynne Chatterton the "School Scheduling Program" (SSP). No one realized how many supporting programs would be necessary to get the scheduling system operational in the schools. (There were nine basic programs in the final Stanford School Scheduling System.)

School Scheduling Program--The basic program. SSP operated heuristically, meaning according to a logical rule of procedure (heuristic algorithm), not a mathematical one. It builds the schedule of classes the way one would do it by a logical trial and error thought process. One of the major decisions that was made and built into the program was to give first priority to maximum satisfaction of student course requests. For example, SSP assumed that it was better to schedule a student without a conflict than to refuse him a course because a class was oversized. It then became a later human judgment by the school to decide to remove him for reasons of overloaded classes. The consequences of this and other such programming judgments were later compensated for in various ways in the computer operation, including the genesis of the other Stanford School Scheduling System programs.

SSP operates by taking the school specifications and generating time patterns, course by course; then rapidly searching and researching to come up with an optimum combination of time, teachers, rooms, and students available for each course and course section. Each decision is based on a previous one on a one-shot basis at any particular time during the schedule building, without backtracking to deschedule and reschedule students or sections. This lack of descheduling was a departure from Oakford's earliest theoretical idea to build the master schedule in one step.

The pioneer schools. It seems to have been Allen who pushed to get things going in the summer and fall of 1962. He lined up the four schools who agreed to work with him on the educational innovations that were his

focus of interest (and theirs) if Stanford would build the schedules for it. Two of these schools were in California: Homestead High School in Sunnyvale and Lincoln High School in Stockton. A third was Marshall High School in Portland, Oregon, a large urban school (approximately 2,000 students). The fourth was the very small (under 200 students) Virgin Valley High School in Mesquite, Nevada. Of these, Marshall High School under the principal, Dr. Gaynor Petrequin, and the project director, Roy Carlson, became an extremely fertile source of many of the educational features now associated with Variable Modular Scheduling. Marshall's innovations are described in Dr. Petrequin's book, published in 1968, Individualizing Learning Through Modular-Flexible Programming. The way they entered the project will illustrate what happened from the side of one of the first four schools.

Marshall was a relatively new school with a staff generally favorable to experimentation. They had already begun to explore better ways to use student and teacher time to encourage individualization of instruction. In 1962, after consultation with Stanford, a proposal was submitted to the Portland Public Schools to participate in the Stanford project, and funds were requested under the Oregon Program, mainly for in-service training of school personnel for the new venture. (The Oregon Program was a cooperative program to improve education in Oregon, supported by Ford Foundation funds and involving the State Department of Education, Oregon colleges and universities, and local school districts.) The Marshall plan was accepted, with a $60,000 grant from the Oregon Program, and a substantial contribution from the Portland School District in terms of materials, facilities, and administrative services. In early 1963, the staff at Marshall was asked to decide how best to design their courses without the limitations of a traditional schedule, and there followed several months of decision-making and preparing the input data for the computer scheduling. (They began with 105 modules on a weekly cycle--21 twenty-minute modules per day--and extended the school day by 40 minutes.) They opened in September 1963 with one of the first computer-generated master schedules--it was relatively primitive and required considerable improvisation to get it working. They prepared for the new schedule with various staff workshops over the summer and an intensive two-day workshop for all staff just prior to the opening of school.

Genesis of the computer programs. In late 1962 the big push began to get a scheduling system operational that would meet the commitments to the four schools. Although the master schedule generator, SSP, was well conceptualized by then, actual writing of the computer programs did not begin until January 1963. Only as that began did the staff begin to realize what supporting programs there would have to be; and as input data from the schools arrived in March and April to be processed, other unanticipated programs were found necessary. "It was a real scramble--at times working 16-hour days and 6-day weeks--from January to August to get the programs written, the data processed, the back-and-forth consultations with schools accomplished, and the schedules finally completed." Everyone was working in the dark. The Stanford staff did not realize what kinds of demands and restrictions would come from the schools, and the schools did not know what to expect from the computer output.

"It was blood" getting it done, but the main features of the Stanford School Scheduling System were completed that year, consisting of programs written as the need became apparent.

. SAP (Student Assignment Program) was born out of the difficulties of trying to assign students to sections of multi-phased courses. In SSP's search, phase-by-phase and course-by-course, class sections were balanced as it went along by partitioning students into them consistent with the student's availability. It was found that this early locking of a student into one section when he could perhaps as well have been assigned to another often created unnecessary conflicts when it came to his next phase or next course request. So SAP, still a major program in the system, was written to load the students into sections at a later stage after the master schedule of classes was worked out.

. RAP (Room Assignment Program) was written for essentially similar reasons--it was discovered that a better schedule could be arrived at sooner by shuffling most room assignments at a later stage.

. The SSP Audit (later called INCA, "INput Card Audit") was forced by the unforeseen magnitude of errors in the input data prepared by the schools (e.g., student requests for non-existent courses, teacher assignments for non-listed teachers, etc.). SSP had been written to check for all such possible errors as it generated the schedule, but this turned out

to take much too long a time. So these testing portions of SSP were pulled out and made into a separate preliminary program. SSP then did not begin its operations until the input data was clean.

. Translation programs. At the output end, it became evident that there had to be a way to convert the master schedule into the kinds of other lists expected and needed by schools. PTWS (Program to Write Schedules) was written to sort the class lists coming out of SSP into room, teacher, and student schedules. A TRANSLATE computer program translated PTWS' numeric codes into names and numbers intelligible to the school.

. Updating programs. A program was written to read in the manual changes and adjustments made after the first or second preliminary schedule runs. Another program updates the original class lists in the light of any changes necessitated by the SAP or RAP student and room assignment programs.

Apparently, each of the four schools had a contingency traditional schedule ready, and indeed the final schedules got built only at the last minute. Marshall High School received its schedule and assorted lists on the Friday before school was to open on Monday. They had to break down all the unfamiliar computer printouts over the weekend to get ready to open. Homestead High School ran for three weeks on a traditional schedule before they were ready to try to implement the new schedule.

Cycles of development activities. The feedback from schools and the Stanford developers' attention to it tended to split two ways: the "I can't live with this part" or "why can't you do it" reaction on the technical side; and the "what are other schools doing with . . ." or "we worked out a good idea for . . ." on the educational side. Development activities also went in these two directions and followed a pattern of yearly cycles based on the building of schedules for each school year.

On the educational side, there was a broad framework of university level theoreticians, school practitioners, and nationally recognized experts in curriculum and other educational theory. The role of the school consultants on the development staff was described as a kind of cement holding this all together in the search for viable educational practices related to variable scheduling. The consultants organized and ran the conferences and workshops that brought these groups together. They kept in constant contact with the participating schools assigned to them, with a conscious effort made to

communicate through a specific liaison person at each school. While they were involved at the university level, they had usually been school practitioners and understood both sides.

The consultants had to learn to orient themselves to the computer technology side of the project. During the first two years, especially, their activities were much more technically oriented than in succeeding years, because of the necessity of getting the system mechanically operational. And they continued to perform the main liaison function--explaining to schools the technical requirements, getting schools to define their ideas specifically enough, advising on workable instructional patterns and course structures, and working out compromises to arrive at acceptable schedules. But their interest was centered on educational innovation, and they felt their greatest accomplishments came in terms of loosing the creativity within the various school staffs. Then they often came in as devil's advocate: "Why do you think that will work?" "Is that really a good idea?" "Our experience shows that this didn't work at another school." Or they became facilitators and coordinators to encourage the school in successful practices to get closer to what its staff really had in mind.

When a plan for a school finally jelled, then the consultant's major effort turned to making it workable in terms of the scheduling technology so that the school could open with that plan. During the first year, of course, much of their work went into the initial design of input and output data forms and helping schools manage the complex specifications required. This continued to a lesser degree, since the system was revised every year on the basis of feedback from the year before.

Allen was constantly traveling, "spreading the gospel." Schools became interested this way and through word-of-mouth as the project grew. The consultants would be sent out to talk to schools that inquired. Or individual schools or school districts would invite someone to make presentations, and the graduate student consultants supplemented their incomes through consulting fees and travel expenses for this kind of thing.

There were one-week workshops every summer at Stanford on subjects related to variable scheduling, with various educational experts giving presentations on things like curriculum ideas, role behaviors, teaching methods, materials and facilities. A few large invitational conferences

were held also, devoted to a specific topic. The 1965 conference on computers in American education has already been mentioned. There were two "performance criteria" conferences held in connection with the vocational education part of the project (1966 and 1967). These focused on how to build curriculum based on performance rather than "time spent" and how to develop student performance measures to this end. Experts on behavioral objectives, writing instructional "performance criteria packages" and tests, or on other aspects of individualizing instruction participated.

The yearly cycle of activities can best be described beginning with the feedback conferences that were held each year in October or November, attended by representatives from the participating schools. (Activities related to these will be discussed in the next section on Formative Evaluation.) The technical staff began programming revisions in fall and winter, while the consultants' activities slowed down, except for answering inquiries from prospective interested schools or individuals. By spring the consultants became heavily involved with data collection and building the following year's schedules for their assigned participating schools. The technical and production staff began the associated data processing and the building of preliminary schedules.

A preliminary schedule was turned out using four basic computer systems programs: (1) the audit to clean up the input data; (2) SSP, the basic schedule-building program; (3) PTWS (Program to Write Schedules) which built teacher, room, and student schedules; and (4) TRANSLATE. With experience, the consultants learned to analyze the schedule sufficiently at this point to tell whether it was headed for acceptability or disaster, and to go back to the schools with recommendations for changes before proceeding further. (The TRANSLATE program made the preliminary schedule intelligible to school personnel.) From April to September, both consultants and production personnel worked extremely hard to "get the schedules out the door"; by spring the programming work essentially had been done.

The process of schedule construction fell into four main phases. The first two, data preparation and construction and analysis of the preliminary schedule, have just been described. These two phases were repeated until an acceptable schedule was arrived at. The third phase typically entailed reading in the modifications to the accepted schedule via the update computer

programs and loading students and assigning rooms via the SAP and RAP programs; again TRANSLATE would generate the printout of the various lists required by the school. Phase four came on or around the opening day of school and provided for changes in student course requests, with reshuffling of student assignments (SAP program) and updating of all the lists accordingly.

Problems and bottlenecks. Many of the problems facing the project staff have already been described or implied; for example, the chronic overestimation of what could realistically be accomplished in any one year. Project staff and funds were fixed resources, which could not be expanded to meet time deadlines when unanticipated delays arose in programming or other areas. This kind of problem seems to have been met by a combination of crash overtime work and trade-offs of funds and personnel from other projects.

A turnover of personnel also presented difficulties, especially as the project grew, as did the use of a certain number of "drafted" graduate students not especially committed to the project. Maintaining a trained production staff year to year was not possible, using part time students and others as data processors on a seasonal basis. So the actual production--turning out the schedules each summer--was a bottleneck in getting the schedules to the schools.

In the first year or two, especially, there were problems in getting schools to identify "bugs" before final schedules were generated. This was apparently partly due to school administrators' uninformed expectations of computer infallibility--"they tended to believe the computer output even if it was wrong." Forms were sent out to schools asking for information on suspected errors (such as a teacher scheduled for two sections at the same time), but very little response was obtained. Probably this was mostly due to the sheer volume and unfamiliarity to school personnel of the page after page of coded computer printouts they received. In a book co-authored by two successive principals of Claremont High School, California, which joined the project the second year, the authors described the frustrations from the school viewpoint. "During the first year we never did fully understand the vast majority of the output data we received or how best this data might serve us in analyzing our master schedule." They recall with irony

the message from the Stanford School Scheduling System staff which accompanied the mass of computer printouts: "Please analyze the following data for conflicts as quickly as possible and return for subsequent changes." Claremont High School is still operating on Variable Modular Scheduling. The book, The Flexibly Scheduled High School (Wiley and Bishop, 1968), gives a description of variable scheduling in general and its implementation at one school. It was actually the schools which had to iron out any such undetected errors, after school began, and the Stanford staff would hear about them at the fall feedback conference. Later, as schools became more familiar with the whole process, many of these errors were corrected in the summer scheduling.

A continuing problem, related to the whole larger task of adjusting systems capabilities to school demands, was what might be called the gimmick syndrome--schools often requested every possible new feature whether they really needed it or not, or knew how to use it properly. This tendency to "ask for the works" without really analyzing requirements undermined scheduling effectiveness. One complex scheduling feature, "phase sequencing," added the third year and dropped the next, will illustrate this. Phase sequencing was a legitimate educational demand. Schools wanted to automatically schedule, for example, one meeting of Phase 1, then a meeting of Phase 2, and then two meetings of Phase 3, followed by another meeting of Phase 2, before the cycle began again at Phase 1. This was programmed into the system and used effectively by a few schools. But it was misused by so many others placing so many restrictions on their scheduling that it was judged not adaptable to a generalized master schedule-building system. When a bad schedule came out and the staff went back to the school, they found that the school had no real concept of why they were asking for this--it was available so they were just using it wholesale. Phase sequencing can still be done, but it is not internal to the system; it is done explicitly in an extra step for courses where it is really needed.

Another sort of problem came from schools not really committed to the educational ideas for change. One story, told by a former Stanford School Scheduling System school consultant, will illustrate a staff member's perception of the effort that was sometimes wasted and the kind of unjustified

bad publicity the project sometimes received. The school in question, a large one with over 2,000 students, wanted a traditional schedule built in order to become more familiar with the technical side of it before committing themselves to a variable schedule. This was done, and they were happy with the conflict-free traditional schedule they received and operated under for one school year. During that time, they requested and received $60,000 under Title III (ESEA) for resource centers and other help in converting to a variable schedule, which they prepared to open with the next fall. In the meantime, there was a change in administration. The first schedule run was not a good one, and in the usual way the school consultant went over it with the school to make improvements. According to him, the second run built a very good schedule, one comparable to those other schools considered successful. The next time he heard of it, he was in Japan during the summer and saw a newspaper story there about computer foul-ups connected with scheduling that school--"the computer put kids in lunch all day long" and other such statements. He was afraid he had missed something crucial, had "really blown it," but when he got back to try to straighten it out, the school administrator insisted it was too late and that it was an unlivable schedule. After the consultant really dug into the schedule, he found other things wrong but not the ones that had been alleged, and the administrator did retract the more sensational allegations, saying he had been misquoted. The consultant later heard by word of mouth that the man was simply looking for reasons to reject going to a variable schedule after the commitment of resource money had been received. The $60,000 went for resource centers at the school, and some students were released from regular classes to go to them, but the school never departed from a traditional schedule.

Final Stanford School Scheduling System development. At the end of the first three years of operation and formative evaluation (see section below on Formative Evaluation), a preliminary production model was considered ready. Evaluation and refinements to the system continued in the building of schedules for increasing numbers of schools in 1966 through 1968 (see flow chart on pages 35-38), supported by the Office of Education vocational education grant. But, beginning in late 1966, attention turned to questions of dissemination.

It became clear that university sponsorship was to end when the basic research was accomplished. Interest in variable scheduling was increasing, and already exceeding the capacities of the Stanford School Scheduling System staff. Most schools currently being scheduled were eager to continue. Two separate lines of diffusion began to emerge: (1) a major effort was undertaken to make the system more widely available to interested users and assistance was welcomed from other universities; (2) a group of the developers began to think about continuing to service the current schools on their own.

It was visualized that the Stanford School Scheduling System would be used by school systems, by university schools of education, and by private companies contracting to service schools. While the state of Oregon, where many cooperating schools were being scheduled, prepared to offer some assistance on state operated computers, both Michigan State University and the University of Iowa also began to plan to make SSSS available through their computation centers. The priority project during 1967 and 1968 became the translation into a more widely used computer language adapted to the next computer generation and the preparation of a final set of programs on magnetic tape with accompanying explanatory manuals.

The final Stanford School Scheduling System programs became available in the IBM FORTRAN IV language for use on the IBM 360-40 or larger computer. The computer used during development was a previous generation IBM computer, the 7090. The language used during development, as previously described, was a special Stanford-adapted computer language, SUBALGOL. To encourage widespread dissemination of the system it was necessary to translate to a more general language. The new IBM 360 computer was just being introduced in 1966, and the decision on the language narrowed down to a choice between FORTRAN IV, basically a scientific language, and PL/1 (Programming Language 1), a more universal kind of language designed especially for the larger computer. PL/1 was favored, both because of ease of translation and because it had more potential for universality. But the IBM compiler program for it, although forthcoming, was not yet ready and it was uncertain when it would be. (A compiler program converts English-like instructions into comparable machine instructions.) So FORTRAN IV was selected.

The translation of the basic systems program, SSP, was done by a systems analyst from the Iowa Educational Information Center (IEIC), the

computation center for the University of Iowa, which was asked to assist in the task. The University of Iowa had developed a student load scheduling program and followed with interest the development of both the Generalized Academic Simulation Program at MIT and the Stanford School Scheduling System at Stanford. In the translation of SSP they were supplied with the other Stanford School Scheduling System programs. Apparently because of overlapping personnel and other ties between IEIC and Measurement Research Center, a private educational data processing organization, the latter gained some early access to the Stanford School Scheduling System. After a pilot project in 13 schools, beginning in March 1968, Measurement Research Center went on to become a major competitor of Educational Coordinates, which was founded by some of the Stanford developers. The Stanford School Scheduling System was released to the public domain in October 1968. Meanwhile, the project had been disbanded at Stanford.

Formative Evaluation

Referring again to the flow chart, it will be seen that continuous revision based on formative evaluation went on during the first three operational years (1963-1966). It actually continued through to the end of the project, but became increasingly a matter of refinement rather than major modification. In 1964, 26 schools were scheduled, including the four from the first year, although one of the four (Homestead High School) dropped out in September and did not use the schedule. In 1965, 33 schools were scheduled, including all from the previous year. By 1966, when 50 schools were scheduled, the system was considered past the experimental stage. The schools scheduled during this formative period, both public and private, ranged in size from 120 to 2,600 students and were distributed geographically over most regions of the United States. The heaviest concentration was in California, Oregon, and Colorado. Other states were Arkansas, Delaware, Florida, Iowa, Michigan, Minnesota, Missouri, Nebraska, Nevada, New Hampshire, Pennsylvania, Utah, and Wisconsin. The American School in Yamato, Japan, was also included. As defined by the developers, the scheduling effectiveness ranged from "acceptable," meaning approximately 90 percent of student course requested satisfied, to "excellent," 98 percent of course requests satisfied.

Formal formative evaluation was conducted by way of annual feedback conferences held six to eight weeks after the opening of school in the fall.

These were typically two-day sessions in which participating school personnel aired their problems with the schedules they had, made suggestions for improvement, and exchanged ideas on educational practices. The first conferences tended to be very oriented toward technical problems--difficulties with preparing input data and understanding output data, and unanticipated "unlivable" aspects of the schedule. However, from the beginning some of the weaknesses discussed impinged on educational issues and this led to various attempts by way of the previously mentioned workshops and conferences at schools to support the schools in resolving these issues.

Apparently there was no other organized formative evaluation, no special questionnaires or official notification forms or channels. However, a large amount of informal collection of evaluation data went on all year by way of telephone calls, letters, and face-to-face contacts. Often, school personnel were around Stanford off and on during the summer, working with their schedules, and would talk to Oakford or Chatterton about their technical concerns or to Allen and others on more strictly educational matters. As discussed earlier, a great deal of the staff's energy was spent in clarifying the feedback that came in--finding out what the schools were really saying.

Feedback from the schools led to changes every year in the scheduling algorithm and input and output design, and to expansion of the parameters of the system. (By parameters is meant the limits on school input for number of students, number of courses, time cycles, etc., that the system could handle.) These were forced by both technical scheduling problems and by the development by schools of new instructional methods they wanted considered. In addition to these revisions due to educational demands, the technical staff continually improved internal systems components on the basis of experience; i.e., conceived faster or more efficient ways of programming or data processing.

Procedure for modification. Modifications on the basis of formative evaluation results were made after a sifting process that led to a definition of priorities. Immediately after the feedback conferences in the fall, meetings began to be held to sort out what might be feasible to attempt the following year. Taken into account were the results of the feedback

conferences and typically up to 300 catalogued items accumulated informally over the previous year. Lynne Chatterton apparently took most of the responsibility for a centralized collection of the latter. Out of these meetings (scheduled informally and with shifting attendance) came decisions by order of priority. Then a commitment in writing was made to schools, saying in effect, "next year we will try to do . . . ." These decisions immediately became fairly binding, not only because of commitments to schools but because they entailed starting new programming and generating new input and output forms. Occasionally, it was found only later that one of these decisions unexpectedly would require such major systems revisions that it had to be rescinded.

The basis for the decision-making was staff judgment plus school pressure. Generally, if the consultants first, and then the technical staff, were not convinced, the thing was not done. The feedback items were evaluated in terms of the number of times they appeared, their generalizability, the importance of their educational impact, their difficulty to do, cost, and so on. Some items could be discarded right away as invalid or unimportant and were never heard of again; others were immediately judged serious and necessary to try to do. In the area in-between sometimes an item was given too low a weight, only to turn up again constantly and insistently--then it would be put in as a priority later or the next time around. In these cases, sometimes the staff turned out to have been right the first time--"we just produced reams of paper that no one ever used"--and it would be dropped again as an expensive waste. Other times the staff simply hadn't understood the school operations well enough, and the item turned out to be a valuable addition to the system.

A continuing problem was that through excess of zeal, response to pressure, or simple miscalculation, more was promised each year than could get done within time limitations. The programming was often late, for example, thus holding up the schools' input, and summers were always hectic because of this kind of extension of time requirements.

Modifications based on feedback. Three very important systems modifications came the second year as a result of the experience with the operating schedules in the four pioneer schools. These will be discussed and later systems modifications briefly summarized before going into the repercussions from the educational side.

The Stanford School Scheduling System is described as an adequate scheduling tool for the first year, but not yet an appropriate <u>educational</u> scheduling tool. A major immediate concern was the control of students and teachers through different phases of the same course. The system could schedule complex multi-phased courses, but it did so by treating each phase independently. The result was that it did not take into account any continuity of teacher to students through the phases, or of teacher assignments, or student groupings. Sometimes this did not matter, but most often schools wanted to insure that a student in a certain section of the first phase of a course met with the same teacher, or the same group of students in a next phase; or that members of a particular teaching team could follow through all the phases of a course. The technical term for this is "interphase dependency," and the valid educational demands for it were met through major system changes in the second year. No attempt will be made to explain the complex technical solution worked out, but the result was two new program features--ESS (Exclusive Student Sectioning) and TV (Teacher Variable associated with student sectioning). These are major features of the present system and allow, if necessary, for students and/or teachers to follow one branch through all sections of a course. The following diagram illustrating some teacher and student grouping dependencies is adopted from Table I of the Oakford, Allen, Chatterton article (1966/67):

	Phase 1	Phase 2		Phase 3			
	(One Section)	Sec.1	Sec.2	Sec.1	Sec.2	Sec.3	Sec.4
Teacher Team A,B,C,D	A,B,C,D	A,B	C,D	A	B	C	D
Representative Students W,X,Y,Z	W,X,Y,Z	W,X	Y,Z	W	X	Y	Z

A third somewhat related feature, Day Independence (DI), was also invented for the second year. This insured that two different phases of the same course would not get scheduled on the same day, if not desirable (usually it was not desirable).

Other systems improvements included:

. System parameters were expanded, for example, from a limit of 350 pupils per session to 750.

. A time reservation code was added to automatically handle restrictions on available times; for example, a student absent during certain hours for outside religious training or a room intermittently reserved for band practice. Such small exceptions had caused large problems when they had to be inserted into the schedule by hand.

. Capabilities were introduced to schedule rooms in combinations and schedule more configurations of teacher assignments within teacher teams.

. Overriding options were instituted to circumvent most systems assumptions (break the rules). For example, the system would not allow a section to be scheduled without an available teacher; a school can specify that this be ignored and the section scheduled anyway, with a teacher being assigned later by hand.

. Solutions to problems arising from unscheduled time were built in. A new program, SOUST (Scheduling of Unscheduled Time), scheduled time previously unscheduled back into the schedule, as directed study for certain students, for example. Also, the system had built the schedule starting from both ends of the school day, which resulted in most unscheduled time falling on either side of the lunch period. An option was added to permit building from the morning only so that this time fell more toward the end of the day.

The most immediately apparent, and still the most perplexing, problem arising from variable scheduling was unscheduled time. Although provision for independent study, including an emphasis on "homework" done during school hours, was an integral part of the Bush and Allen educational design, no one realized the extent of unscheduled time that would emerge in a variable schedule. The developers did not foresse the "jigsaw puzzle" problem discussed earlier (density versus variability). With the variability in course structures that the first four schools wanted, the schedule came out with 20 to 40 percent unscheduled time. Furthermore, because of the way the computer built the early schedules, this unscheduled time tended to fall in large chunks for numbers of students at one time, a situation which schools were not prepared to handle. There were a number of administrator

conflicts and other reasons why Homestead High School left the project the second year, but one of their problems was "those Tuesday afternoons." With requests for many three-meetings-per-cycle course structures, the computer search pattern very efficiently scheduled a lot of Monday-Wednesday-Friday classes. Large numbers of students were simply unprepared to use the free Tuesday and Thursday time wisely.

A great deal of study has gone into the use of unscheduled time since then, and the computer system now has a "density control" factor that spreads out this time more evenly. Many educational concepts now considered an integral part of Variable Modular Scheduling came in part out of creative attempts to solve this problem.

That first year, in fact, the term everyone used was "independent study." It was Dr. Gaynor Petrequin at Marshall High School in Portland, Oregon, who suggested simply calling it "unscheduled time" because there were many possibilities for its use. He began setting up certain options to give students definite alternative choices for constructive use of this time. These included special projects under assigned teachers, access to resource centers and laboratories, tutorial sessions. From these early beginnings at Marshall came many of the features described earlier in this report under Product Description, such as prerogative or "mini-" courses and open laboratories.

The open laboratory concept is an illustration of the way educational ideas and scheduling problems combined to evolve new school practices. It was soon discovered that any large blocks of time reserved by a school in its initial input specifications created severe problems for scheduling efficiency (i.e., maximizing the satisfaction of student course requests). Schools therefore soon abandoned the attempt to specify 2-, 3-, or 4-hour laboratory sessions in art or science, for example. Individualized laboratory assignments proved to be one good solution for unscheduled time. In addition, teachers found that student concentration did not always hold up well in the long required laboratory periods they initially thought educationally desirable. The result was a return to shorter scheduled laboratories in traditional laboratory-oriented subjects and the evolution of "open laboratories" in these and many other subject areas. The open laboratory is simply an appropriate facility, supervised by a teacher,

that is available to students during unschedule time. A German teacher, for example, required only two scheduled modules per week but, in addition, required students to go to the "language laboratory" for a total of 10 more modules. He used individual learning packages, student tutors, and audio-visual equipment, as well as work with students during his own unscheduled time, to let each student progress through the course at his own rate. In its most open form, the "open laboratory" can become the vehicle for a totally performance-oriented curriculum. For example, the entire math curriculum at Kailua High School, Hawaii, was organized with no scheduled meetings whatsoever, but with students working through prepared curriculum units under the open laboratory concept. As a result of this kind of experimentation, the project schools increasingly became able to expand the number of courses a student could request. Another trend was an increase in small-group offerings.

SUMMATIVE EVALUATION

No summative evaluation has been conducted on Variable Modular Scheduling.

DIFFUSION

Agency Participation

Diffusion of the final Stanford School Scheduling System is done through Professor Oakford's office at Stanford University. Educational Coordinates, Inc., conducts all diffusion activities related to Variable Modular Scheduling (i.e., the extensively revised Stanford School Scheduling System, discussed below).

If Educational Coordinates receives an inquiry on the Stanford School Scheduling System itself, they direct it to Stanford. Some people still buy it--Boeing Aircraft is said to have purchased it recently. Conversely, if Stanford receives inquiries on variable scheduling in general, they refer them to Educational Coordinates because the Stanford School Scheduling System is obsolete in terms of the many refinements that have been made in actual school scheduling.

Diffusion Strategy

Stanford University

No diffusion strategy was delineated for the Stanford School Scheduling System at Stanford University. As noted below, the diffusion activities conducted by Professor Oakford's office at Stanford were rather limited.

Educational Coordinates

The strategy decided upon by Educational Coordinates the first year, 1968, was to put the major marketing effort for variable scheduling into the holding of general educational conferences in different parts of the country. They felt their best avenue to success was to associate themselves with important movements in educational innovation of all kinds. At the same time, they advertised their capability for computer-generated traditional schedules by sending a brochure to a large number of secondary schools around the country. The latter effort produced little at the time--"they didn't know who we were and no one was very interested." From the 15,000 or so brochures sent, only 500 inquiries came back; these were followed up, but very few contracts resulted. The idea behind this was not only to bring in revenue at a time the company was most concerned about keeping continuity of scheduling with the developmental schools without losing money, but also to improve new traditional schedules to the point where schools would see the opportunities in variable scheduling. This idea proved valid as time went on.

Except for that one brochure, there was no budget for promotional literature, other than an initial newsletter to contracting schools, followed by a few more such newsletters on a sporadic basis over the next two years. That first year they also took every opportunity to help interested new schools with the preparation of funding proposals and/or conducting systems analyses and design of instructional programs tailored to the individual school situation. And, this has continued on a consultant fee basis, although it is not actively promoted.

The philosophy behind Educational Coordinates' dissemination strategy from the beginning to the present was expressed as follows: To focus on defining the kinds of schools needed to help individual students prepare for the kind of world they will be living in, and then promote the kinds of

substantive, meaningful changes that have enough potential interest to be translated into operational realities. Thus, the heavy emphasis on general conferences, as well as seminars, workshops, and in-service training. The more people who begin thinking "Is there a better way?" the more interest there is in innovative possibilities and ways to expedite them. The computer scheduling is billed as a tool--that is, a bad schedule will produce a bad educational program, but a good schedule will not produce a good program. As with the school consultant assistance, Educational Coordinates aims at supporting schools in any way possible to help them use the tool effectively.

Actual Diffusion Efforts

Stanford University

Dissemination of the final Stanford School Scheduling System itself was done through Professor Oakford's office at Stanford. An initial explanatory booklet was widely distributed at the time of the public domain announcement in late 1968, and is still available (Oakford, Allen & Bush, 1968). The Stanford School Scheduling System was made available to any interested purchaser on a service charge basis to cover distribution costs (approximately $350 at first, now up to $500). The buyer received the set of programs on magnetic tape, and detailed documentation consisting of a Data Processor's Manual and a School Manual describing the forms and data cards and other information on school input data preparation. The developers' original idea that the system would prove economically and otherwise feasible for use by large numbers of schools or computer service organizations has not been borne out. This seems to be both because the programs themselves are quite complex and because the successful tailoring of scheduling practices to school educational goals is a kind of art that is hard to acquire. An Educational Coordinates spokesman said it takes them a year to really train a new person to be helpful to them on the technical side and likened the tailoring of the schedule to the use of a carpenter's tool: "Given a saw, a guy who's never sawed a board before can probably get through it, but it's different from giving an experienced carpenter the same saw and board."

Educational Coordinates

Educational Coordinates was initially formed in order to continue servicing the schools being scheduled and to keep alive the educational

philosophy behind the Stanford project. While it was incorporated in February 1967, it did not commence business operations until December 1967. The figuring to arrive at the pricing policies to present to schools if they were to continue the service was done by going through Stanford records to try to drop out development costs, then adding to what it would probably cost to continue the operation, with about a 20 percent profit margin, to arrive at a per pupil cost to schools. The result was a price three to four times what schools were used to paying under the subsidized Stanford project. According to Coombs, the assumption on which the pricing was based was that they were looking for long-term credibility. Although this was quite a jump for some schools and Educational Coordinates didn't know if they would have any customers, the reasoning was that if the system was not worth enough for schools to pay for it, it was better to find that out right away. On the other hand, some made a good case for pricing it even higher at first in order to build up a better research and development base to be plowed back into schools experimenting with it, and then lower prices as operations expanded. According to the founders, the major motivation behind these and other decisions was to spread the concept--make sure the tool was used. Apparently, Educational Coordinates began with shoestring capital--"we had no money." (The initial contract with schools required their paying half the price in advance.) The final decision was to price it as fairly as possible on the basis of what it really cost to do it and remain financially solvent. A side consideration given was that if it were priced higher and still went well, "charlatans" might be attracted into the field. (There was, of course, no patent protection.) At the fall 1967 feedback conferences, schools were told that the project was ending at Stanford, and in December schools were notified by telephone that Educational Coordinates had been formed to continue the service.

New Developments

After the Stanford School Scheduling System public domain announcement in late 1968, the management of Educational Coordinates made an all-out conscious effort to develop as many improvements and increased potentials in the system as they could that next year. Consequently, in 1969 Educational Coordinates developed major new dimensions, changes, and improvements,

based on the developers' accumulated experience and new ideas. The revised system is what has been referred to, in this report, as Variable Modular Scheduling. According to Educational Coordinates, they worked 15-hour days, six days a week, to make the system different and better to justify their own competitive existence.

Three major improvements made that year and in 1970 are briefly described (SSP, the central program, did not change):

1. SAP, the Student Assignment Program, was completely rewritten. It took five months to finish it, and Educational Coordinates claims it is an unequalled sophisticated and exhaustive student-load type program.

2. Day Separation. The feature of "day independence" avoided scheduling two phases of the same course on the same day but was tied to the interphase dependency feature of ESS (Exclusive Student Sectioning). In the new system, these two features could be used independently.

3. Density Control. This changes the computer search patterns so that scheduled time was spread out on a more uniform basis in the cycle. That is, the computer would schedule only 60 percent or so on any one day and then move on to another day, eliminating undesirable large chunks of unscheduled time for too many students at once.

Many other changes then and since (approximately 30 new features) are too technical to be described in the scope of this report. Most of the others have been not so much major systems changes as either internal efficiency steps or user-oriented input/output improvements important to school customers. For example, what are called VERITAL (Verification Tally) and CLASVER (Class Verification) produce input data tallies, giving the school preliminary verification lists of student course requests both by individual student and by course. Input and output forms were redesigned the first year.

In terms of parameters, the number of allowable sections in a course phase has been increased from 35 to 50 and the number of students per course to 1,000. In response to the growing desire of schools to go to shorter term lengths, the system can now build semester or shorter period schedules as well as a full year's schedule.

Feedback conferences and modification procedures. Educational Coordinates continued the same yearly feedback conferences and similar formative evaluation

procedures as went on during the Stanford development. They have a systematic method of collecting and establishing priorities for modifications based on feedback collected throughout the year. Each year they go through the loose-leaf notebook full of items starred *, **, and so on, in terms of priority and whittle them down to the most important and possible in terms of time and other limitations. Following this, some modifications would be built into the current production model and others would be undertaken as research and development activities. The feedback has become less and less technically oriented and more and more oriented to educational issues. This is one reason for the company's growing emphasis on curriculum and general educational consulting activities.

The feedback conferences have been split each year by geographical area--one on the West Coast and one on the East Coast. They are paid for by Educational Coordinates as part of the service to the customer schools, which send representatives to them. In keeping with the increasing importance of educational versus technical questions, Educational Coordinates plans to change the format somewhat this year to individualize the sessions and provide more alternative forums for discussion.

General conferences, workshops, seminars, and in-service training. In 1968, seven or eight general conferences were organized in different parts of the country. The next year there were fewer; in 1970 there were about ten. These conferences are often jointly sponsored by school districts where variable scheduling is already in operation. Educators are invited to speak on areas of their own interest, including people from universities, government, regional educational laboratories, and private research organizations. The topics are general ones.

Each year, beginning in 1969, approximately 40 to 50 seminars were held in major cities across the country. At the opposite pole from the large general conferences, seminars usually involve announcements sent to a selected group of people in one area, and are billed as discussions of variable scheduling and topics directly related to it. Fees are charged in the $20 range, and they are attended by 10 to 20 people. Usually one or two speakers from an Educational Coordinates regional office make the presentation, including films, which focus on the rationale and the strengths and

weaknesses of variable scheduling. Apparently most potential customers are attracted by way of these seminars.

In between the general educational conferences and the seminars, which are a more direct promotional operation, are various workshops on a variety of topics. Registration fees are similar to those of the general conferences. One was held in July 1971 with the theme, "Finding Ways to Make Innovations Successful," and most of the workshop leaders were school principals, vice-principals, and Educational Coordinates consultants. For example, one of the presentations was given by the principal of a school using "daily demand" scheduling, a different approach from that of variable scheduling, and another was by a principal of a school using a high density (low variability) Variable Modular Schedule.

In-service training to schools requesting it has been a growing dissemination tool, partly because more money has been available to schools for teacher training than for some other things. Also, schools see it as a way to get their personnel informed on the latest techniques. Educational Coordinates has worked with schools to help the staff learn how to write behavioral objectives, or has used the micro-teaching format as a vehicle for teacher training. In-service training has been developed most under Robert Kessler at Educational Coordinates' Boston office; his school consultants concentrate on this aspect. More directly related to Variable Modular Scheduling are in-service training sessions on small-group methods of instruction, or work with particular curriculum departments on designing course structures. In-service training becomes an indirect sales tool in that the more skills school personnel develop, the better able they are to successfully handle the options available under Variable Modular Scheduling.

Computer facilities. In 1968 Educational Coordinates bought time on Stanford's computer. Since then they have rented time on various computers, east and west, according to the best available rates. At present they are using one computer facility, located in Boston and tied to the West Coast by tele-transmission lines. While the company is trying to build up their standard data processing business for the non-peak period of the year, it is not yet cost effective to have their own computer facility, especially considering the cyclical nature of the scheduling load.

Schools scheduled. In 1968 Educational Coordinates built schedules for 102 schools in 87 school districts in 25 states and Japan. Some of these were continuing schools from the Stanford project and some were new schools. In 1969, 112 schools were scheduled, of which nine were traditional schedules. In 1970 variable schedules were built for 156 schools, plus another 50 traditional or semi-traditional school schedules. The 1971 figures are not complete but are expected to show a small increase, perhaps to 160 schools. By 1969 the company was offering certain discount arrangements for scheduling several schools in the same district. A simulation schedule will be run for an interested school on a special basis. A simulation is much the same as a first schedule run and enables a school to get an idea of the problems and advantages before commiting itself to an actual scheduling contract. A simulation schedule built for Punahou School, Hawaii, in the fall of 1970 became, in fact, a first regular schedule run after the school decided to go to a variable schedule in January.

As indicated, Educational Coordinates is building traditional schedules for schools. This has not only produced income for the company, but has also been a vehicle for generating interest in variable scheduling. A subsidized conference held in the San Francisco Bay Area to promote traditional scheduling produced a very good turnout. But when the conference began, it developed that most of the participants did not want to talk about traditional scheduling--the time was spent in talking about variable scheduling and Educational Coordinates' services for it. Educational Coordinates' only real attempt to market through a sales force arrangement was in the area of traditional scheduling. They hired a man with a background in education who was also interested in marketing and let him go his own way to try to generate traditional scheduling and data processing business. He worked through mailing lists, followed up leads, and built contacts over a year's period. He brought in the first contract in which Educational Coordinates did both the scheduling and all other data processing for an entire school district. For this reason alone his employment proved cost effective, and after he left for personal reasons Educational Coordinates might have replaced him if they had not had to backtrack on their planned expansion. Some of his leads later led to more scheduling business.

It was found that once schools had the experience of a satisfactory computer-built traditional schedule they tended to begin asking for variability, sometimes little by little. So the building of traditional schedules turned out to be one vehicle for the dissemination of variable scheduling.

Product Characteristics Affecting Diffusion

Variable Modular Scheduling entails major restructuring of school organizational patterns. Long-established educational practices related to state codes, college entrance requirements, and the concept that a proper educational environment is based on control of students in contained classrooms are cited as deterrents to the necessary change. It has been a fact that in the first year of a variable schedule student grades have dropped on the average. The problems arising from unscheduled time are very visible, whereas its accomplishments are less easily perceived. Year-by-year experimentation with different instructional patterns is sometimes seen as disruptive to student learning.

Variable Modular Scheduling has gone into the market place at a time when federal funds have become less available and school districts have faced taxpayer revolts, teacher militancy, and other serious financial pressures. While the cost of computer scheduling assistance is not that great, it can become difficult to justify under these conditions, especially in the face of the value changes implicit in major organizational restructuring. There are associated costs also in terms of modification of facilities and staff training if a variable schedule is to be successfully implemented.

Money pressures have been one reason schools have dropped Variable Modular Scheduling, even after successfully implementing it. Often they do not abandon the variable schedule but rather modify it to the point where they can try to work it out by hand based on their computer-assisted past experience. This is particularly feasible for smaller schools.

Some of the unsuccessful practices and associated problems of earlier schools turn away others who might be interested. Sometimes Variable Modular Scheduling personnel say schools have really looked into the situation and have come up with well-documented evidence on which to base

their decision not to try it. More often, they claim, they have simply listened to unsubstantiated rumors of things that never really happened. "Horror stories" about computer foul-ups circulate and myths grow up around events that did not happen the way they sound. One instance given is that Variable Modular Scheduling has been made the scapegoat for problems arising out of racial tensions. What Variable Modular Scheduling personnel call "this pluralism of ignorance about the problems of innovation" has turned many away.

There has been no summative evaluation of Variable Modular Scheduling based on "hard data." Many school administrators legitimately ask for research evidence that Variable Modular Scheduling produces better results in student performance. Variable Modular Scheduling adherents claim that refined experiments are very difficult to conduct because of the nature of the variables involved.

Of the approximately 100,000 secondary and elementary schools in the United States, it is estimated that fewer than one percent use computer-built master schedules. The term "flexible scheduling," however, is widely used to describe any change whatever in a conventional schedule, such as using double periods of time for one course, scheduling a combination of similar subjects to meet at the same time, sequencing various rotations of period meetings from day to day, or offering courses in alternate years.

"Block scheduling" can either fit into a variable modular schedule or can be an alternative to it. As an alternative, block scheduling allows no time flexibility--that is, period lengths are fixed. Homestead High School went to a block program in the social studies department when it left variable scheduling. They scheduled three teachers and 90 students for the same four 55-minute periods of the day, with access to both large and small rooms. In this way, they could vary size groupings and teacher assignments, and include independent study. Within a variable modular schedule, block scheduling is most often used to broaden the curriculum and offer a variety of electives. For example, Williamette High School in Oregon, one of Educational Coordinates' schools, offers 75 courses in its English department by scheduling approximately 750 students and 12 teachers together in a shifting modular block arrangement. So many students

can meet with a teacher for one course one day and another the next, or whatever.

The most used computer-assisted method offering flexibility in the Variable Modular Scheduling sense (i.e., where the master schedule changes every day, including time units) is Daily Demand Scheduling. The idea was first designed and implemented at Brookhurst Junior High School in Anaheim, California, and the approach was computerized by Rex Arnett at Brigham Young University. The schedule is teacher- and student-initiated, usually on a weekly or three-day forecast basis. It operates on a sort of contract whereby teachers and students submit requests to school programmers for varying amounts of time or facilities as required by their course goals week by week. This approach is in use in several forms by schools around the country, usually through their own computer or state computer facilities.

Daily demand scheduling is obviously even more flexible than a variable modular schedule, which is built for the whole year or semester. (The Variable Modular Scheduling system can be changed by computer only by recasting the schedule with all new input data.) However, daily demand is expensive in terms of computer time and the personnel time for continued decision making and input preparation. Variable Modular Scheduling proponents contend that cyclical patterns develop anyway and that the Variable Modular Scheduling provision for up to a 10-day cycle, along with imaginative use of unscheduled time, takes care of most of the real variability that is desired. They also feel it is not cost effective for most school districts to run their own computers. Educational Coordinates considers it could operate a daily demand schedule for a school for approximately half the amount of money the school has to spend, but has not pursued this kind of business.

As noted earlier, Measurement Research Center, a division of Westinghouse Learning Corporation, began development of its own proprietary version of variable scheduling (called Flexible Modular Scheduling) based on the Stanford School Scheduling System at the same time Educational Coordinates did. Starting in early 1968 with a pilot study involving 13 schools, they developed into Educational Coordinates' major (and only) competitor, scheduling 43 schools in 1969 and 73 schools in 1970. They expect to schedule "close to 100" schools in 1971. Five educational consultants, all

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former administrators who implemented the system in their own schools, work with the scheduled schools. Measurement Research Center's continued development of the system has incorporated some improvements, just as Educational Coordinates has. Some date back to their University of Iowa connection during the transition period of 1967 and 1968. The two organizations have diverged in technical approach and emphasis, but no attempt will be made in this report to compare the two.

ADOPTION

Extent of Product Use

Out of the approximately 30,000 secondary schools in the United States, under 250 use a complete variable modular schedule built by computer. A few elementary schools also use the system. The 156 schools scheduled by Educational Coordinates in 1970 included an estimated 150,000 students. Educational Coordinates estimates that they have built variable schedules for approximately 300 schools (including the Stanford development phase); obviously many schools have dropped out and others have entered. There seems to be no one identifiable cause for schools leaving the scheduling system--the major factors are probably money, public pressures, and problems arising out of unscheduled time, as discussed in the previous sections. Many schools seem to drop the computer assistance in order to go it alone, retaining varying amounts of variability while building the schedule by hand. This is true, for example, of two of the four original pioneer schools during the Stanford development. Both the largest and the smallest, Marshall in Portland and Virgin Valley High School in Nevada, have gone to hand-building a variable modular schedule. The third pioneer school that stayed with the system in the developmental stage, Lincoln High School in Stockton, has continued ever since with Educational Coordinates building its schedule every year.

Conversely, some schools stay with the computer assistance but reduce the variability of their schedules in response to problems of one kind or another. Mountain View High School, California, for example, went from a five-day to a two-day cycle, thus getting much higher densities (less unscheduled time).

Other critical factors include what might be called the "bandwagon" effect on the part of school administrators and the "guinea pig" reaction on the part of the public. Some school administrators, apparently feeling the pressure to be "innovative," without real plans or commitment to it, have gone to Variable Modular Scheduling and then poorly implemented the schedules they received. Mistaking the tool for the end instead of the means, they got nothing educationally valuable.

A growing public feeling against too much experimentation has forced an end to flexible scheduling experiments of all kinds. The daily newspaper columns and "letters to the editor" have reverberated with controversy over it. Principals and school superintendents have come under fire and school board majorities have been overturned because of it. Despite this, new schools continue to adopt it, and not all public reaction is negative. The main impetus for one of Educational Coordinates' newest school customers came not from the administration, but from the Board of Education.

Finally, the unanticipated complexities of implementing a variable modular schedule and the associated problems with certain computer-related features have left some schools disenchanted. In a study conducted in 1969 by the California State Department of Education (1970), schools polled gave the following three main reasons for returning to a conventional schedule after some experience with "flexible" schedules of all different kinds:

- Process too cumbersome and time-consuming for the benefits derived.
- Loss of a key administrator who was the prime motivator.
- Staff deciding they could use the same benefits without being locked into a system.

Installation Procedures

Installation procedures were extensively discussed under Description of Materials and will only be summarized here. The major steps in building a master schedule are: Step 1, in which schools compile the input data; Step 2, in which the school prepares the input data cards; Step 3, in which Educational Coordinates develops the schedule; and Step 4, in which the final master schedule is printed in school language. Modifications required

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in physical arrangements, equipment and classroom organization depend upon: (1) what the school has before adopting Variable Modular Scheduling, and (2) the type of schedule they decide to follow. Implementation of Variable Modular Scheduling requires the cooperation of the whole school staff. As noted earlier, in-service training is available from Educational Coordinates. Furthermore, conferences, workshops, and seminars are held periodically throughout the country to help adopters obtain the intended benefits of Variable Modular Scheduling. The type of schedule developed is largely up to the school and they can modify it to any degree they want at any time they want. Public relations prior to and after adoption have been extremely important to the proper installation of Variable Modular Scheduling.

Successful Implementation

The successful implementation of a variable modular schedule, which totally restructures school organization, depends heavily on good planning and staff commitment. In Appendix A, two examples are given of such successful implementation: the adoption of Variable Modular Scheduling by Oceana High School in Pacifica, California, in 1968, and by Punahou School in Honolulu, Hawaii, in 1971. The discussions center on the decision processes that resulted in adoption, the planning for the change over, and some of the problems encountered and advantages realized. (The use of these two schools as illustrations does not imply that others did not implement Variable Modular Scheduling equally effectively.)

FUTURE OF THE PRODUCT

Impact and Expected Use

As already described, Educational Coordinates foresees a similar pattern of modest growth of use of Variable Modular Scheduling as has been the case up to now. This means the actual computerized scheduling. The developers think the impact of the ideas has changed almost every secondary school in the country, and even if the computer aspect were to disappear the manipulation of time, space, and organization would continue. "The ideas are too powerful--they're just not going to die." The computer assistance is expected

to continue to be necessary, however, as the ideas become more complex. The major technical problems in computer scheduling have already been solved. It will become more difficult for schools to defend, on educational grounds, staying on a traditional schedule. Other trends in education related to individualizing instruction are expected to make the scheduling problem even more complex (unless in disappears entirely with 100 percent individualization and no structured group commitments for students.)

In a recent article (Thomson, 1971) the superintendent of Evanston Township High School, Evanston, Illinois, which has been on Variable Modular Scheduling for four years, envisions a "client-centered school" of the future to optimize both individualization and the use of the potential of computer scheduling. He talks about the formation of "diagnostic teams" of faculty and counsellors which would function like admissions committees in universities in that they would gather facts about students' objectives, abilities, interests, attitudes, and needs. Student "profiles" would emerge and be held in computer data banks. Hand in hand with this would be the development of a continuum of highly adaptive instructional modes which could provide specific programs for specific students. It can be seen that if this kind of trend develops in a structured school setting, scheduling complexity would greatly increase.

Possible Future Directions

Apparently, a possible new direction for variable scheduling by computer is toward what is called "interactive scheduling," which has been made feasible only with the third generation of computers. Technically, interactive scheduling means an on-line, real time system to analyze the data "live," so to speak, as opposed to batch processing where the data goes into the computer and then comes out to be analyzed. In practice, related to school scheduling, it would mean a school administrator sitting down at a computer terminal and asking and getting answers to questions as he went along: "I want to schedule this course this way--what will happen?" The computer answers, "I predict this many conflicts. . . ." The administrator answers, "go ahead," or "what if we did this instead," and so on. Many variations would be possible. This kind of interaction might be used only for certain tricky problems, while the rest of the schedule would be done

strictly in the present cycle pattern of input + computer processing + output + analysis; and then repeat.

The idea behind interactive scheduling would be to anticipate the known major problems and make corrections before being locked into a computer-fixed variable schedule which is difficult to change once it is generated. In some ways this trend is a vindication of the original ideas behind the GASP scheduling system developed at MIT, but the increased sophistication of computer technology in the meantime is crucial. In another way, it is a possible alternative to the expense of "daily demand" scheduling, which operates at the present time by requiring new input and computer processing at frequent intervals.

CRITICAL DECISIONS

The following events are a good approximation of crucial decisions made in the 11-year history of Variable Modular Scheduling. For each decision point, the following types of information were described: the decision that had to be made, the alternatives available, the alternative chosen, the forces leading up to choosing a particular alternative, and the consequences resulting from choosing an alternative.

Although an attempt has been made to present the critical decisions or turning points in chronological order, it must be clearly pointed out that these decisions were not usually made at one point in time, nor did they necessarily lead to the next decision presented in the sequence. Many of the critical decisions led to consequences that, in some important way, affected all subsequent decision-making processes.

Decision 1: To Focus on Enabling Experimentation

Bush and Allen began with the general intent to help accomplish educational innovation. They assumed that the democratic ideal of a liberal education for all should be preserved within the framework of the comprehensive public schools. They also felt that needed educational change was hindered not so much by disagreement on what ought to be done as by lack of the know-how to implement it. With this in mind, they narrowed their own focus to enabling experimentation which led naturally to a scheduling approach. The first steps had been taken in evolving modular scheduling

based on variable course structures. Had the developers focused on curriculum or individualization designs, Variable Modular Scheduling may never have developed.

Decision 2: To Tap Existing Technology

The developers were quickly confronted with the real problem of gaining school organizational efficiency and meeting scheduling requirements. They approached Oakford of the Stanford Industrial Engineering Department to ask if the computer could help. Their other alternative was to encourage flexibility through a modification of existing scheduling methods. This alternative was rejected in favor of the final one when pilot studies conducted by Oakford suggested that using the computer was feasible. However, only after three more years of experimentation did a clear picture emerge of the kinds of educational demands and/or restrictions that could and would be made by schools on a scheduling system.

Decision 3: To Formulate a Radical Design Model

The developers were aware that many promising innovations simply could not be fitted into the common high school program of six years of 36 weeks each of 55-minute daily periods of a rigid set of course requirements. Time, they felt, was no way to measure what a student learned, and isolation of required courses and lack of sequencing discouraged continuity. Consequently, they chose to formulate a radical curriculum design model. Beginning by conceptualizing the school curriculum as a two-dimensional area to be scheduled (students x time), they developed a model-building method of curriculum planning. From this model evolved modular scheduling based on variable course structures.

Decision 4: To Employ an Heuristic Approach

Once the decisions were made to use the computer and to employ a curriculum model based on modular scheduling, the developers had to arrive at a practical approach to be taken to actually write computer programs. All kinds of approaches for building the schedule were considered. What emerged was Oakford's basic heuristic algorithm for generating the master

schedule. This meant that programs would operate according to a logical rule of procedure, not a mathematical one. It would build the schedule the way one would do it by a logical trial and error thought process. Thus, priorities, e.g., the satisfaction of student course requests, could be built into the schedules and subsequently modified on the basis of later human judgment.

Decision 5: To Develop a Generalizable Technology

Faced with the commitment to meet the unique demands of various cooperating schools and the basic commitment to certain ideals of educational change, the developers made important conscious decisions. They resisted the pressures to solve school scheduling problems quickly and efficiently on an individual basis and concentrated on the more difficult task of developing the technology in a way that would be most generalizable to all schools. At the same time, when it came to curriculum design they emphasized the uniqueness of the individual school and the necessity for school judgment, as opposed to what one member of the development staff called the "cookbook approach." The latter point was more controversial within the Stanford group itself. The decision to generalize the technology was consistent with the aim of a widely applicable method to help with the desired educational experimentation. But there were some on the development staff who similarly argued for generalizing instructional recommendations--publishing "how-to-do-it" curriculum patterns based on the most successful practices developed in participating schools. The fact that this was not done turned some potential cooperating schools away; they wanted to be told "the best way" to organize beginning English, for example.

This does not mean that the developers did not advise schools on more versus less workable instructional patterns, nor that they did not make many concessions in scheduling to meet the demands of particular schools. They did both. But in terms of educational innovations they kept to a sort of broker function--conceptualizing, naming, disseminating what seemed to be workable ideas, while encouraging schools to use their own judgments and intuition in experimenting in their own unique setting. And, on the

technological side, the basic Stanford School Scheduling System works for traditional schedules, extremely variable schedules, and every gradation in between.

Decision 6: To Follow a Yearly Cycle of Activities

As noted in the text, the developers realized their work was exploratory and needed to be tried out and modified over and over. They decided very early that certain important activities were necessary and should be repeated each year. These activities, as noted on the Major Event Flow Chart, included: spring scheduling of schools; summer training-related activities; fall tryout in the schools; early winter feedback conferences; and finally, revisions and modifications. This cycle of activities helped to prevent many bottlenecks and to overcome the many that could not be prevented. Most significantly, the cycle was repeated after Educational Coordinates took over and initiated new development activities. Thus, significant improvements could be made in the product from its first classroom trial up through its present use in the classroom.

Decision 7: To Form Educational Coordinates

After the preliminary production model was completed, some attention turned to the question of dissemination. The following were clear: University sponsorship would end when the research ended in 1968; interest in variable modular scheduling was increasing; and schools using the system wanted to continue. A group of the developers then decided to continue to service the schools on their own. They developed Educational Coordinates, and decided to promote the system on a national basis. This decision led to more development and more use of the variable modular approach. It resulted in the product, Variable Modular Scheduling Via Computer.

REFERENCES

Bush, R. N. & Allen, D. W. A New Design for High School Education--Assuming a Flexible Schedule. New York: McGraw Hill, 1964.

Coombs, A. F., Jr., Madgic, R. F., Oakford, R. V., Sato, T., & Talbert, R. Variable Modular Scheduling--Effective Use of School Time, Plant, and Personnel. New York: Benziger, Inc., 1971.

Educational Coordinates Flexible Scheduling School Manual. Sunnyvale, Calif.: Educational Coordinates, Inc., 1969.

Holz, R. E. Computer-assisted scheduling. Journal of Educational Data Processing. 1964, 1.

Oakford, R. V. Machine assistance for constructing the high school schedule: an industrial engineer's report. Journal of Secondary Education. 1961, 36, (6).

APPENDIX A: EXAMPLES OF SUCCESSFUL IMPLEMENTATION

Oceana High School

Oceana is one of five high schools in the Jefferson High School District, which serves a population of lower to upper-middle socioeconomic level in an area just south of San Francisco. Oceana serves mainly the lower-middle to middle income group of the coastside community of Pacifica (population 37,000), which also has one other high school. One other school in the district (Serramonte High School) has followed Oceana in adopting a variable modular schedule. Oceana opened in 1962 and has a current enrollment of approximately 1,300 students.

By about 1964 the school had begun to experiment with some block scheduling and team teaching. For example, they combined some English and U.S. history courses in two-period blocks of time on certain days; this kind of thing was also done in science, home economics, and physical education. Otherwise, the schedule was a traditional one.

In going to Variable Modular Scheduling, Oceana chose a five-day cycle with twenty-one 20-minute modules, lengthening the school day in the process. They changed later to twenty-one 19-minute modules in order to shorten the school day to bring it more in line with other schools in the district, although it still runs 20 minutes longer (8:25 a.m. to 3:10 p.m.) than other schools.

Background and Decision

In 1965 Dr. Robert Watt, then vice-principal, attended one of the week long Stanford summer workshops and became very interested in variable scheduling. The following year when he became principal, Oceana began to experiment with some released time related to the block scheduling. They also were exploring ways to eliminate some of the problems in the block scheduling; for example, while some subjects were getting the benefits, others (such as girls' physical education) were operating under handicaps because of it.

It so happened that the same year (1966-67) the National School Board Convention was held at Marshall High School in Portland, Oregon. Dr. Watt attended the meeting along with two board members; all three returned

enthusiastic about what they observed on tours of Marshall and Andrew Jackson High School, which were both operating on Variable Modular Scheduling. On his return, Dr. Watt held a special faculty meeting to discuss the possibility of going to a computer-built variable modular schedule. There followed a carefully planned exposure of the Oceana staff and students to the ideas and practices of Variable Modular Scheduling at other schools.

First, two "pro" and two "anti" department chairmen were sent to Marshall High School in Portland. The district superintendent and his assistant superintendent, along with the principals of the other four high schools in the district, went at the same time. More faculty and department head meetings followed. In the spring of 1967 approximately half the teaching staff and some student representatives were sent to observe Variable Modular Scheduling in operation at various California schools, such as Lincoln in Stockton and John F. Kennedy in Fremont. In the fall all the rest of the faculty and most of the support staff, including custodians, made similar visits.

That fall, also, separate meetings were held with all departments to discuss the pros and cons related to their particular requirements, and in late November a meeting of the entire faculty was held to thrash out further questions.

Throughout this period, the principal had made it known that the change would not be implemented without a favorable staff vote. Certain guarantees were made in response to the concerns of some of the staff; for example, that paraprofessionals would not supplant teaching positions, and a promise to "anti" holdouts that the superintendent would be informed that if Variable Modular Scheduling was voted in they wanted a formal review of it after three years.

In November 1967 the staff voted by secret ballot. The results were 73 percent for and 27 percent against. A detailed proposal was then submitted to the superintendent, and approval to go ahead was given in December for implementation of Variable Modular Scheduling in the fall of 1968.

Implementation

A three-phase plan with a timeline of priorities had been included in the original proposal, most of which was carried out as planned. (The major

exception was a hoped-for summer workshop for staff members; for budget reasons this did not materialize.) The first two phases were carried out during the remaining the remaining semester of the 1967-68 school year and over the summer.

Phase 1 began with the establishment of a social science resource center in an existing library conference room, staffed by hiring an additional clerk-typist and utilizing free part-time services by library and teacher trainees from two San Francisco colleges. Students were given released time for independent study in the resource center.

Consultations were begun with staff from other schools on Variable Modular Scheduling to discuss potential problems. In addition, the assistant principal for guidance, some counsellors and department heads, and an attendance man were sent again to Marshall High School to find out more about how to resolve conflicts and make other program changes after the final schedule was built.

Plans for community and student orientation were developed and carried out, as described below.

Phase 2 centered around all the decisions on what kind of variable modular schedule would be instituted and the actual work with Educational Coordinates to get the schedule built. The entire staff was involved in the decision-making on length of cycle, length and number of modules, and the other time patterns associated with variable course structuring. Each department submitted its recommendations for team teaching, large and small group instruction, open laboratories, and resource centers. A four-man team prepared the actual input data--the principal, Dr. Watt; his vice-principal; the assistant principal for guidance; and a counsellor.

The school had begun to work with Educational Coordinates the previous fall when the decision to go ahead was in the final stages. Early the next semester a Saturday workshop was held with Educational Coordinates for counsellors, administrators, and other staff to get some background on deciding module size and time patterns. Students were counseled on the preparation of course requests. With the help of two people from Kennedy High School experienced in preparation of Variable Modular Scheduling, and careful reading of the Educational Coordinates School Manual, the scheduling team put together the input data forms. At that point, the Educational

Coordinates consultant looked them over and announced that they had done their homework well--he had to make very few changes. After analysis of the first prediction run, which was not satisfactory, the complete second run schedules came back to the school in early May. Each teacher had a chance to review it for errors and changes. By the end of school in June the third schedule run gave what was considered a satisfactory schedule. Oceana received a great deal of help from Educational Coordinates on the mechanical aspects--the consultant was available whenever there were questions and helped in the analysis of the schedule runs. Once school opened in the fall, however, "we had to fly by the seat of our pants" to resolve the everyday operating problems. (There was no alternative schedule ready to fall back on.)

The third phase was concerned with actually getting operational, including in-service training and the planning for more resource centers, a needed large lecture room, and other facilities modifications once the schedule began; and with plans for evaluation of the first year's schedule.

During the spring and summer before the school opened on Variable Modular Scheduling, over half the faculty attended an in-service course prepared and conducted by people from San Francisco State College. The course was specifically aimed at training in large and small group instruction, individualized instruction, team teaching, and the use of audiovisual and other resource materials.

When school began, plans went forward for reorganization of resources and modifications of facilities to provide teacher office space and additional resource centers. Some additional cost was involved in this, but much of it was done by restructuring already available resources. Beginning in November, resource centers were established in English, Science/Mathematics, and Practical Arts during the 1968-69 school year. Rooms were selected in terms of their proximity to the library or the instructional center.

Community and Student Organization

During the semester of the building of the schedule, Dr. Watt spoke to numerous groups of parents and community organizations on the forthcoming move to Variable Modular Scheduling. The community groups included the Chamber of Commerce, the Rotary Club, and others. Press releases were prepared, and considerable newspaper publicity was received. He spoke not

only to Oceana's own PTA, but to the PTA's of all the elementary schools feeding students to the high school.

Student preparation included meetings with the eighth graders who would be entering Oceana in the fall. Each returning class (grades 9-10-11) was given orientation sessions to prepare them for the new schedule.

Operations--Some Problems and Advantages

When school opened in September 1968, the principal said that for the first two or three weeks "we thought the din would never end," but that settled down as time went on. The most immediate and continuing problem--the "Achilles' heel of a variable modular schedule"--was attendance reporting. It is easier for students to cut classes and harder to account for teacher time. Apart from the question of wise use of unscheduled time, parents expect to be able to immediately locate their children at school, which is difficult to do under Variable Modular Scheduling conditions, and there were many parental complaints. In addition, despite Dr. Watt's commitment to the educational principle of giving students more responsibility for their own learning, he feels that high school cannot be run like a college. The school owes 14- to 18-year-olds some guidance and direction in respect to the effect of immature decisions on their grades and learning. It took most of the first year to get the attendance problem really manageable, but student misuse of the system has greatly decreased since then, in any case. The interim solution the first year, when they were inundated with "cut" slips, was to put four administrators in charge of one grade level each to track down the problems. Sometimes it turned out to be a matter of course "overlaps," actually an advantageous feature of Variable Modular Scheduling but one which disturbs attendance accounting. (Overlaps occur when a student is allowed to take two chosen courses even though their meeting times overlap somewhat. Under a traditional schedule a student obviously could not take both music and French if the meeting times were the same. Under a variable schedule, French might meet during modules 4-5-6 and music during modules 6-7-8, leaving only a 19-minute overlap, and the student can make arrangements with both teachers to arrive one module late or leave early in accordance with circumstances.) The present attendance system calls for taking attendance in each class, but "cut" slips are sent in only after a teacher accumulates three unexplained absences.

For similar reasons, teacher attendance was not easily monitored, and a small minority of teachers caused some minor administrative problems from time to time. It is relatively easy under Variable Modular Scheduling to simply dismiss a class for a day, or not keep arranged office hours.

There were departmental differences in reaction to the new schedule. In keeping with reports from other Variable Modular Scheduling schools, the math department felt not enough sustained class time was given them. The music department felt there was insufficient group practice time. For the most part, however, only minor adjustments have been necessary since the first year.

The clerical staff had adjustments to make. Their work environment was totally changed because of noise and students constantly coming and going, instead of all being quiet for 50 minutes at a time.

The increased student accessibility to both administrators and teachers made demands on their time that were often tiring; but the rewards of getting to know students better apparently compensated for this.

Staff

Variable Modular Scheduling enabled Oceana High School to release a teacher to work full time in a reading center with individual problem readers, which had not been possible before. It also made possible a closer working relationship with the teacher intern program at San Francisco State College, whereby Oceana has teacher interns working every day at little cost while still taking their college courses. Six of them are currently employed; they begin as teacher aides at first, and by the second semester are experienced enough to free six regular teachers for more work on curriculum planning.

Extra paraprofessionals have been hired for the resource centers without changing the ratio of the regular teaching staff to student enrollment. A full-time aide in the social science resource center coordinates the other three centers, which are staffed by six part-time employees working half-days. This has been an additional cost to the school, but one which they claim is not directly related to Variable Modular Scheduling since paraprofessional help would have been needed and asked for under any schedule.

A major cost-related difference in staff utilization was documented by Oceana for the first year of Variable Modular Scheduling--a sharp drop

in expenditures for substitute teachers. In 1967-68, $17,000 was spent for substitute teachers. The next year, with the introduction of Variable Modular Scheduling, the amount dropped to $9,000, for a total savings of $8,000 in substitute teacher salaries.

Evaluation

Variable Modular Scheduling at Oceana is in its third year (1970-71) and will be continued. Many changes and modifications have been made, based on experience, and a formal evaluation report was submitted in each of the first two years (Watts, et al, 1968, 1969). Such a demand developed for copies of these from other interested schools that Oceana finally had to begin charging for them. Because the school was being evaluated the third year by the periodical accreditation procedures of the Western Association of Schools and Colleges, no separate evaluation was done.

The internal evaluations compared such things as honor roll, attendance, number of teacher conferences, use of resource facilities, and student grade averages. No attempt will be made here to detail the evaluation results of the first two years. Most were consistent with reports by other schools on Variable Modular Scheduling. Library use jumped by 56 percent in the first year, for example, including the resource centers. Curriculum innovation was greatly expanded, and curriculum and instructional practices updated through performance objectives. Going to a variable schedule forced reexamination and specification of departmental goals in performance criteria terms. More one-to-one working relationships with students developed.

Predictably, based on other schools' experience, average grades dropped the first year. Some students who had not been doing well did better; some who had been good students slumped noticeably. But overall, the average pattern over three years was estimated approximately as follows:

Year 1: A's and B's were fewer; C's remained about the same D's and F's increased markedly.

Year 2: Grades moved back toward previous conventional levels but on a skewed curve--there were more A's and B's, fewer C's, and more D's and F's.

Year 3: A's and B's increased over what they had ever been on a traditional schedule; the number of C's rose a little but remained fewer than under a traditional schedule; D's and F's moved up to about their conventional level before the start of Variable Modular Scheduling.

Evaluation plans for the 1971-72 school year center on devising ways to measure student performance, which has not been done systematically up to now. The faculty will be asked to devise valid measures of achievement and growth, and pre- and posttesting is planned.

Questionnaires to teachers, students, and a sample of parents (40 per grade) were sent out at the end of the first year. Student and teacher response was described as overwhelmingly in favor of continuing the new schedule; parent response was about 50-50 pro and con. The second year the same questionnaires were sent; except that this time they were sent to all parents (973 families), of which about 45 percent replied. Fifty percent of the parent replies received were favorable, 13 percent said they saw no difference, and 37 percent were unfavorable in varying degrees. (The questionnaires did not have to be signed.)

In a staff vote conducted the third year, 80 percent opted to continue and 20 percent wanted to return to a more traditional schedule. These percentages after three years were close to the original decision vote of 73 percent for and 27 percent against. There had been the normal staff turnover in the meantime, but although the staff was assured of the opportunity to do so, no request for transfer had been made for stated reasons related to the new schedule.

Dr. Watt expressed the opinion that the central question facing school administrators and staff on a variable modular schedule is how to best adapt the curriculum and instructional practices to take real advantage of the scheduling tool. The technical problems have become minor; with experience, they have the yearly scheduling mechanics "down to a science." Oceana has worked out its own special system for changing student schedules by hand after school starts, which is more difficult to do under Variable Modular Scheduling than under a traditional schedule. They have opted to assign rooms by hand during the schedule generation in order to discriminate on the basis of how far teachers have to walk, something the computer can't "know." In terms of educational features, Dr. Watt and the majority of the staff are pleased with the new system. Open laboratories, especially, have worked well. But they are still wrestling with how best to add and restructure courses, how to develop learning activity packages and projects that will encourage students to use the resource centers, how to buy or develop the best learning materials for the still inadequate facilities

and audiovisual equipment they have. And finally, he feels, they have not regressed but neither have they progressed in reaching the same average of eight to ten percent unmotivated students who formerly sat through classes without learning or in the Dean's Office for disciplinary reasons and who now visibly misuse their new freedoms. Some more optimum combinations of structured and variable time patterns is needed for these students. This experience has apparently been universal in schools going to Variable Modular Scheduling.

Punahou School

Punahou School is a large, prestigious K-12 private school in Honolulu. Its secondary school, almost entirely college preparatory, has long had a reputation for excellence. It is well-equipped with facilities and resources. Cooke Library is considered an outstanding resource center, with extensive audiovisual materials, including videotape facilities. Until 1970 Punahou operated on a traditional schedule, with nine periods a day of approximately 45 minutes each. In going to a variable modular schedule, the school chose a six-day cycle (14 cycles per semester) and twenty-six 15-minute modules per day. (A six-day cycle does away with any identification by days of the week. Days simply become A,B,C,D,E,F, with the cycle beginning again on Day A, so that neither holidays nor vacations interrupt the sequence.) The longest classes under the new schedule become seven to eight modules (1-3/4 to 2 hours) and the shortest two modules (1/2 hour). Unscheduled time varies from 20 percent for freshmen to 50 percent for seniors.

Background and Decision

Punahou had contact with the concept of flexible scheduling as early as 1960 when the principal at that time talked to Allen at Stanford; he did not feel then or in succeeding years that the computer system was well enough developed to be of serious interest to Punahou. In 1966 Kailua High School in Hawaii went to Variable Modular Scheduling; and two years later, in 1968, Kailua staff members gave a progress report on their schedule to the Punahou staff. This sparked the interest of Mr. Winston Healy, then dean of administration, who was to become principal of Punahou in 1969.

In the meantime, during 1968, Mr. Healy instigated the formation of a committee to investigate various possible ways to vary period lengths.

In addition to interest in Variable Modular Scheduling, some of the reasons behind this were the burgeoning of elective courses over the previous several years and administration- and faculty-initiated experiments, such as released time for students in some subjects, pass/fail grading, and teacher-student "contract" courses in some departments. For example, the English department had simply been dividing its classes, letting half the students leave the room while the other half had a seminar discussion period. Both the art and science departments were using double period laboratories as much as they could under a hand-built schedule, which had to place 1,600 students in over 7,200 course requests with 55 available classrooms. The school already had a math resource center, a language laboratory, and other special learning facilities which the staff felt were not being used to full advantage under the traditional schedule.

The deliberations of the committee (composed of both teachers and administrators) were expanded in late 1969 to include the possible option of going to a computer-built variable modular schedule. At the same time, an "experimental modular schedule" was tried out on a limited basis in the 1969-70 school year. Essentially, the experiment involved scheduling classes every other day, completing the normal five days in a two-week cycle, and using time variations of 30, 60, and 80 minutes. It was based on trying to accommodate the requests of some departments (science, art, history, and others) for longer periods of time, while maintaining the needs of such departments as math and language for short periods of intensive work. The results of the experiment were mixed. Most teachers disliked the 80-minute modules. However, most of the faculty liked the variability within and between days and the advantages it offered; for example, an entire videotape could be seen in one class period, field trips were facilitated, and more individual work with students was possible. In the meantime, the committee had already begun discussions with Educational Coordinates and contacted Kailua High School again about its experiences with Variable Modular Scheduling. (In November 1969 a seminar sponsored by Educational Coordinates was held at Punahou.) Department chairmen and teachers were consciously keep informed on the increasingly positive attitude of the committee toward trying Variable Modular Scheduling.

Also, during early 1969, Punahou's master schedule, although still hand-built, was student-"loaded" for the first time by a local computer. This familiarized the school staff to some extent with computer printouts of class lists and with computer capabilities in general.

Finally, the five-year accreditation assessment was being made during this period by the Western Association of Schools and Colleges. The self-evaluation at Punahou connected with that intensified the evaluation of their educational goals and the assessment of facilities, resources, and teachers also being done in the investigation of variable scheduling.

The result of all these related activities was that what was to have been simply an experiment with variable time patterns became an intermediate evaluative step leading up to the adoption of Variable Modular Scheduling. Exploratory contract negotiations with Educational Coordinates began in early 1970. After evaluating the results of the recent experiment, the committee recommended that a simulation schedule be generated, and by March 1970 a contract was signed with Educational Coordinates for a simulation schedule for 1970-71 with an option to move to a fully built schedule the second semester. In effect, this meant a "double" schedule for 1970-71 at almost twice the cost of usual schedule-building. The normal traditional schedule was built for the year, and school opened on it in September. That fall the simulation schedule was built with the idea that, if the simulation looked good enough to try out Variable Modular Scheduling the second semester, the school could still return easily to its available traditional schedule if Variable Modular Scheduling failed drastically.

Implementation

To prepare for the simulation schedule, intensive teacher education began in general faculty meetings and departmental and sub-departmental meetings on the requirements and responsibilities involved in creating a variable schedule. Mr. Healy, the principal, initiated a series of memos to the faculty, planned in a logical progression from introductory explanations and guidelines to decision deadlines (number and length of modules, cycle, course structure designs, etc.) to actual input data preparation. Due to inexperience on both sides, there apparently was an inordinate amount of time and energy spent in some departments on plans which did not meet administrative standards or computer capabilities. A three-man schedule

team composed of Mr. Healy, his administrative dean, and one English teacher made the final judgments on the feasibility of the departmental requests after going back and forth between Educational Coordinates and the faculty to resolve the questions raised. The schedule team worked nights and weekends to accomplish the necessary coordination and preparation of input, as well as to complete their own self-education and the education of teachers, students, and parents in working out the schedule. That fall of 1970 was described as chaotic but exciting and stimulating for the schedule team--"the way to learn something is to do it, not just to study it." Constant communication was maintained with Educational Coordinates on technical problems, but there was little discussion with them on educational objectives. Kailua High School gave excellent assistance in input preparation by warning about certain kinds of requests that usually "bombed out" in practice and helping to determine workable parameters. In addition, each Punahou department head met with his Kailua counterpart to discuss instructional patterns and curriculum practices. (Punahou's decisions were not actually influenced by any extensive evaluation of Kailua's program, since the two schools are quite different in student population, courses offered, and many other respects.)

By November 1970, a simulation run had been completed. In December it was analyzed and refined, and the go-ahead approved to have the complete schedule built for the following semester. The simulation thus became the first computer run. In late January 1971, Punahou began operating on a variable modular schedule for grades 9 through 12.

Community and Student Orientation

Throughout 1969 and 1970 parents were kept briefly informed of developments through meetings of the PTA executive board. However, it was felt that until a definite decision had been made and more experience acquired, there was little to be gained by involving parents in the earlier stages. Students were informed of the ongoing plans through monthly meetings of each class (freshman, sophomore, etc.). In keeping with Punahou's college preparatory emphasis and tradition, explanations to parents and students stressed some of the similarities of Variable Modular Scheduling to college time patterns and college student responsibilities. Students were counseled in the fall of 1970 when their actual course requests for the simulation were submitted.

In early March, after the schedule had been in operation a little over a month, a special meeting attended by 700 parents was held to formally introduce the workings of the new schedule to parents. The program was "multiphased," in line with the Variable Modular Scheduling concept of multiphased courses. The first phase was a "large-group presentation," a speech by Principal Healy, explained as covering two modules (1/2 hour). In the second phase, parents broke into smaller groups for discussion and questions. A special brochure entitled "Variable Scheduling at Punahou" (1970) was handed out, covering the educational philosophy behind the adoption of a variable schedule, along with an explanation of school policies and of some definitions and terminology ("module," "unscheduled time," "overlap," etc.). Finally, some "common questions and answers" were listed including the advantages over a traditional schedule and the question of student control and learning during unscheduled time. The latter was predictably the major area of parent concern, particularly for 9th and 10th graders. A key part of the presentation to parents was to encourage them to look at the schedule as a tool in relation to their children as individual learners. For example, it was pointed out that some 9th and 10th graders might actually have too <u>little</u> unscheduled time, while some 11th and 12th graders might have too much.

<u>Operations and Evaluation</u>

The above-mentioned concern of the parents of younger students had been largely met already in the initial planning. In any case, because of graduation requirements, freshmen and sophomore schedules changed less than those of upper classmen. In addition, all freshmen were automatically placed in 45 minutes of supervised study daily, as were selected sophomores according to either school decision or parent request.

Meetings and notices of all kinds to teachers and students accompanied the opening days of the new schedule, as the need arose, and although there was initial dissatisfaction on the part of about 20 out of the 80 faculty members, the schedule apparently got off to a relatively smooth start.

Some unanticipated technical problems came in adjusting "overlaps," attendance taking, and broken interphase dependencies. The problems of unwise use of unscheduled time, increased "visibility" of behavior problems,

and a further decrease in academic achievement among the poorer students were about as expected. Ninth and tenth graders were found less able to cope with the unstructured time pattern than had been foreseen. (Juniors and seniors liked it even when they didn't use it well.) As expected, noise levels rose, especially in the library. The student lounge was so littered by a minority of problem students that the student association voted to close it down. A somewhat surprising reaction from students was concern over the sharp reduction in time available for club meetings, which seemed to reverse what had been growing apathy toward clubs in the recent past. Both students and faculty regretted the reduction of assemblies, and concern was expressed by some about the new schedule's effect on cohesiveness and school spirit.

The new schedule worked best for art, English, social studies, and advanced foreign language classes. It seemed to prove least effective in mathematics, although use of the math resource center rose markedly. The science department especially liked the easing of cramped facilities and the increased time for teachers to prepare for experiments, but there were problems in synchronizing irregular laboratory periods with material to be covered in other phases.

In terms of budget, it was reported that aside from the extra money for the generation of the schedules, the only significant cost in implementing the schedule was the creation of 18 new teacher offices. It was also stated that the use of two-fifths of a teacher less under the variable schedule just about covered the scheduling costs. Neither the yearly budget nor spending priorities have changed appreciably, although a coming building renovation planned five years ago will be done very differently now that the school has changed from traditional to variable scheduling.

Immediately after the variable schedule went into effect, the faculty council appointed a committee to evaluate it. In the ensuing two months, several meetings were held by Mr. Healy with each department chairman and with the class deans to evaluate what was happening; and each student class council sent out questionnaires and tabulated the results. At the end of that time, a vote was taken on whether to plan to continue the experiment the following year. Voting anonymously by departments, 74 of the 80 faculty members voted to continue it subject to certain modifications. There were

six dissenters. Both the deans and the department chairmen voted unanimously to continue, again with modifications. The students voted to continue, with majorities in each class; the majority was most substantial among seniors and most marginal among freshmen.

In April 1971, Punahou began to plan for the generation of another variable schedule for 1970-71, correcting for the disadvantaged observed. Obviously, after such a short time in actual operation, Variable Modular Scheduling is still considered an unproven experiment at Punahou. Equally obvious, its mid-year implementation, despite inevitable discomforts and anxieties, went well enough to satisfy the majority of participants that it was a worthwhile change.

APPENDIX B

LIST OF PRODUCTS AND DEVELOPERS

The following is a list of products for which Product Development Reports will be prepared.

Arithmetic Proficiency Training Program (APTP)
Developer: Science Research Associates

CLG Drug Education Program
Developer: Creative Learning Group
Cambridge, Massachusetts

Cluster Concept Program
Developer: Dr. Donald Maley and Dr. Walter Mietus
University of Maryland

Developmental Economic Education Program (DEEP)
Developer: Joint Council on Economic Education

DISTAR
Developer: Siegfried Engelmann & Associates

Facilitating Inquiry in the Classroom
Developer: Northwest Regional Educational
Laboratory

First Year Communication Skills Program
Developer: Southwest Regional Laboratory for
Educational Research & Development

Frostig Perceptual-Motor Skills Development Program
Developer: Dr. Marianne Frostig

Hawaii English Program
Developer: Hawaii State Department of Education
and the University of Hawaii

Holt Social Studies Curriculum
Developer: Dr. Edwin Fenton
Carnegie Education Center
Carnegie-Mellon University

Individually Prescribed Instruction--Math
Developer: Learning Research and Development Center,
University of Pittsburgh

Intermediate Science Curriculum Study
Developer: Florida State University
Dr. Ernest Burkman

MATCH--Materials and Activities for Teachers and Children
Developer: The Children's Museum
Boston, Massachusetts

Project PLAN
Developer: Dr. John C. Flanagan and the
American Institutes for Research

Science: A Process Approach
Developer: American Association for the Advancement
of Science, Commission on Science Education

Science Curriculum Improvement Study
Developer: Dr. Robert Karplus, Director
University of California, Berkeley

Sesame Street
Developer: Children's Television Workshop

Sullivan Reading Program
Developer: Dr. M. L. Sullivan

Taba Social Studies Curriculum
Developer: San Francisco State College

Talking Typewriter
Developer: Omar K. Moore and Responsive
Environments Corporation

Variable Modular Scheduling
Developer: Stanford University and
Educational Coordinates